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CONTENTS

	Page
Peace and Atomic Power	741
Water Requirements under Desert Conditions. By Dr. B. McArdle	744
Gathered Nature Stories. By Seton Gordon, C.B.E.	744
Audiovisual Aids in the U.S. Armed Forces. By Lieut.-Col. Eric Lowe	745
Geographical Approach to the History of the British Isles. By D. B. Harden	746
Fish Farming in the Middle and Far East. By Dr. C. F. Hickling	748
Max Planck Memorial Ceremony at Göttingen. By Prof. E. N. da C. Andrade, F.R.S.	751
Lyon Playfair and Technical Education in Britain. By W. H. G. Armytage	752
Obituaries:	
Prof. F. O. Bower, F.R.S. By Prof. J. Walton; Sir Edward Salisbury, C.B.E., F.R.S.; L. J. F. Brimble	753
Mr. J. L. Chaworth-Musters. By H. W. Parker	755
News and Views	755
Letters to the Editors:	
Ultracentrifugation and Electron Microscope Studies of Tissues of Inbred Strains of Mice.—Prof. R. D. Passey, Dr. L. Dmochowski, Prof. W. T. Astbury, F.R.S., Dr. R. Reed and Dr. P. Johnson	759
Molecular Arrangement in Tobacco Necrosis Virus Crystals.—Roy Markham, Dr. Kenneth M. Smith, F.R.S., and Dr. Ralph W. G. Wyckoff	760
Synthesis of Adenosine Triphosphate.—J. Baddiley, A. M. Michelson and Prof. A. R. Todd, F.R.S.	761
Photochemical Degradation of Starch.—Dr. S. Peat, F.R.S., Dr. E. J. Bourne and W. J. Whelan	762
Quantitative Chromatographic Estimation of α-Amino-Acids.—Dr. L. Naftalin	763
Quantitative Paper Chromatography.—R. B. Fisher, D. S. Parsons and G. A. Morrison	764
The Fourier Method of Crystal Structure Analysis.—Dr. W. Cochran	765
A New Fourier Refinement Technique.—Andrew D. Booth	765
Spectral Sensitivity of Lead Telluride Layers.—T. S. Moss	766
X-Ray Investigation of the Structure of Jute.—M. K. Sen and H. J. Woods	768
Animal Tissue Culture with a Synthetic Medium.—Dr. F. Jacoby and S. J. Darke	768
Nutritional Requirements of *Drosophila melanogaster*.—Dr. Michael Begg and Dr. Forbes W. Robertson	769
Botanical Nomenclature of the Shaddock or Pomelo.—Dr. D. Chatterjee	770
Significance of Pollen Dimorphism in Late-Glacial *Armeria*.—Dr. G. Baker	770
Demonstration of the Heart Beat.—Dr. Ian F. S. Mackay	771
Proposed Central Publication of Scientific Papers.—Sir George Thomson, F.R.S., and Dr. J. R. Baker	771
Theory of the Structure of Clay Minerals:	
Tailed X-Ray Reflexions from Random Layer Lattices. By Dr. A. J. C. Wilson	773
Banded X-Ray Reflexions from Clay Minerals. By Dr. G. W. Brindley and J. Méring	774
Inheritance of Sex Forms in *Luffa acutangula* Roxb. By H. B. Singh, S. Ramanujam and B. P. Pal	775
Plant Virus Research at Cambridge. By Dr. Kenneth M. Smith, F.R.S.	776
A New Microscopic Principle. By Dr. D. Gabor	777
Agricultural and Related Products of the British Colonies	779
The Human Factor in Industry	780
Parallelism between Atomic and Planetary Properties	780
The Forest Research Institute of Sweden	781

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PEACE AND ATOMIC POWER

IN his stimulating study entitled "The Free Society", Mr. Middleton Murry gives reasons for believing that pacifism is as real a peril to freedom and democracy as is communism. The policy of avoiding war is a very different thing from preventing war, and in making plain the direct challenge which Russian Communism offers to the free society, Mr. Murry insists that the greatest obstacle to the effort to prevent war and to put civilization on a basis of security is blindness, unconscious or wilful, to the actual designs of the U.S.S.R. We have yet to see how far events since Mr. Murry's book was written have opened the eyes of the world to those designs; but many will agree with him that the world cannot live indefinitely under the strain of present suspense, knowing that at any moment civilization may be struck down by the final catastrophe. We must avoid a world war at almost any cost, and this he argues can only be done either by a universal world-authority to coerce a nation which refuses to obey its decision, or by an incomplete world authority to compel a nation which refuses to enter it. The crucial test, he considers, will come over the question of the control of atomic energy.

Mr. Murry is prepared to consider a world war for the purpose of abolishing war; he thinks that if the U.S.S.R. persists in refusing to accept the only conditions under which the control of atomic energy is possible, the nations which are prepared to put this new power under international control should create the atomic authority, with all that it involves in the renunciation of independent national sovereignty, build up a world in which this system is in force and issue an ultimatum to the U.S.S.R. making her acceptance of such control the alternative to war. He sees clearly all that is implied in the creation of an atomic authority and the inevitable erosion of the present fabric of Russian ideas if Russia once enters such a system. But he is probably too sanguine as to the possibility of bringing home to the Russian people the nature of any such dispute, and making them realize that the nations that want control as the only means of eliminating war have no aggressive designs on the U.S.S.R. There is little evidence to suggest that public discussion in any true sense of the word is possible or probable in the U.S.S.R., or that the close grip of the small governing group on the mind of that nation, and its thorough grasp of the means of communication and publicity, are likely to be loosened by any ordinary means.

There is some support for part of Mr. Murry's argument in the admirable discussion of the international implications of atomic energy recently issued by a Chatham House Study Group*, and to which frequent reference was made in a debate in the House of Lords on February 18. The report gives a very clear picture of the scientific and technical background and of the position of the plans for international control up to September 1947; and it is

* Atomic Energy: its International Implications. A Discussion by a Chatham House Study Group. Pp. 128. (London and New York: Royal Institution of International Affairs.) 4s. net.

provided with a good bibliography. It is thus well designed to assist in awakening and enlightening public opinion on the importance and the extreme urgency of this world problem; but it contains little in the way of constructive proposals, and there is some divergence of views among the contributors—a divergence which was made even more manifest in the House of Lords debate.

In the first chapter of the report, Sir Henry Dale attempts to define the objective and to explain the difference between the American proposals, as well as those of the Atomic Energy Commission, and the counter-proposals of the Soviet Government. While he recognizes that the latter are consistent with the principles that have hitherto governed that nation's policy, like Mr. Murry he points out that they cannot be regarded as having any useful relation to the actual situation, with its growing danger and the consequent urgency of finding a solution. The problem will not be solved by waiting on natural developments, and in the present situation the preservation of national sovereignty as claimed by the U.S.S.R. must come to mean the retention by every nation of an unquestioned right to prepare in secret for the annihilation of others. Moreover, even the abandonment by agreement of all attempts to use atomic energy as a source of power for an agreed period of years, as suggested by two American engineers, would not facilitate international inspection or avoid all suspicion of interference with industrial activities without agreement on the requisite surrender of national sovereignty. Once conceded, that alone might provide a first step towards a world government of international relations under the United Nations, and eventually to complete disarmament.

It is in the second part of the report that differences of opinion are considerable; but one chapter in this part, on nuclear energy in war, bears closely on the recent Defence White Paper and might well have received comment in the House of Lords debates. This omission supports the contention of the report that without public understanding and support on a large scale, no democratic government could make appreciable progress in imaginative planning and adaptation of the national structure to accord with the requirements of defence. The present need is a constructive approach to this difficult problem in which all sections of the professions and the business community alike would have to participate. An intelligent compromise between the ideal requirements of defence and those of social and industrial progress could only emerge from an educated and powerful body of public opinion.

The Statement Relating to Defence, 1948 (Cmd. 7327) may help to form that body of opinion; but it contains little to supply an answer to the question whether we have reached a point at which national defence is becoming dangerously inefficient and inadequate. It is couched in much too general terms for any external judgment to be possible, especially in the important section dealing with research and development. The statement that research and development continue to receive the highest priority in the defence field both in the allocation of manpower and materials and in the provision of finance was questioned in the debate; and the White Paper itself refers to difficulties through the general shortage of qualified scientific and technical staff and troubles over the supply of labour and materials.

The Defence Research Policy Committee has devoted considerable attention to the establishment of priorities in this field, with the object of concentrating work on a smaller number of items of the highest importance. A high proportion of the total expenditure on defence research and development is devoted to general aeronautical research and to the development of aircraft with improved characteristics of speed, range and carrying powers. Problems of high-speed flight are being studied by flight trials of research aircraft, both piloted and pilotless, as well as by experiments in the wind tunnel; and other effort is being put into the development of controlled missiles of various kinds with a main object of providing the most effective possible defence against aircraft attack. With this work the Commonwealth of Australia is co-operating fully by establishing a range and an organisation in Australia for full-scale tests.

Further improvements are reported in the organisation within the Commonwealth for the exchange of information on defence questions and for the common study of defence problems; and discussions at a series of meetings in London in November 1947 of the Commonwealth Advisory Committee on Defence Science covered a wide field. The main object of British policy is stated to be the prevention of war, and the White Paper insists that our defence policy must be kept flexible because the conclusions now reached may be nullified, amended or confirmed as further study reveals the lessons of experience and research. New scientific developments do not modify the basic principles of defence policy; but the advent of weapons of mass destruction must profoundly influence both the preparations for, and the conduct of, war. Provisionally, it is held that their existence increases the possibility of surprise attack, since the effort required to deliver devastating attacks with these weapons will be smaller than that which would be demanded by the use of conventional weapons, and that decisive results might be obtained by their use alone.

Acceptable standards of defence are accordingly bound to be raised; and it is satisfactory to note that, in addition to the need for flexibility, the White Paper recognizes the importance of civil defence as well as of greater co-operation within the Commonwealth. Furthermore, in the production of a co-ordinated long-term defence plan within a general but flexible policy on the shape and size of the forces, a severely selective policy is imposed by economic considerations, so as to concentrate our defence effort on essentials; and in this general aim, research and development for all three Services must remain in the forefront. In this connexion the forward planning of the Defence Research Policy Committee seeks to direct activity so far as possible to those projects which may be expected to have the greatest effect upon the conduct of war.

These objectives of the defence policy of Britain arise directly from our obligations and commitments as a great Power, and whatever criticism may be made in detail of the White Paper, its concluding paragraph is well calculated to drive home the relation between peace and power. To form the alert and intelligent public opinion which will support the instant action necessary on occasion to preserve peace is one of the inescapable responsibilities of a great Power intent on preserving peace, and one which requires attention quite as much as the maintenance of forces adequate to meet its commitments. As the White Paper remarks, the extent to which these duties can be fulfilled are conditioned not by the material, technical and economic resources of the country alone, but also by its moral strength.

Returning now to the Chatham House report, one feature common to Sir Henry Dale's introduction and to Dr. H. E. Wimperis's survey of the plans for international control of atomic energy is the generous appreciation of the altruism of the Government of the United States in making its various proposals. Again, in discussing the control of nuclear energy and the development of international institutions, Sir Charles Webster, Sir Arthur Salter and Sir Oliver Franks, after emphasizing, like Sir Henry Dale, the certainty of disaster if the situation is allowed to drift again, emphasize that only the creation of an effective international authority commanding world-wide loyalty and adapted to meet the growing problems of a situation that is rapidly being transformed by technical developments, can enable man to continue to enjoy the 'good life'; but they express the hope that atomic energy will be one of the principal agents which will make possible the triumph of man over his own weaknesses. Their observations on scientific co-operation and professional loyalties in relation to such constructive developments, as well as on staff generally for such an international authority, deserve the notice of men of science, although the human element is discussed more fully by Lord Hankey in a later chapter.

The chief positive contribution of this report lies in the suggestion in the chapter on international co-operation in the development of atomic energy for a corporate atomic research institute. This suggestion, it is true, presupposes that international agreement on the development of atomic energy will be reached, including the creation of a system for regulating the production of nuclear energy and its associated research and development and the banning of the use of atomic weapons. Admittedly the organisation described is purely theoretical; but it does indicate the way in which the opportunity could be created for transforming the self-interest of nations by productive action into a broader group consciousness, and for bringing men together in objective studies which could lead to re-focusing their points of view.

It is difficult to appraise the extent of the influence of a scientific institute of this type on the inherent antagonisms of nations, especially as the first and most difficult step is that of overcoming such antagonisms in order to be able to establish the institute at all. On the pessimistic view developed by Lord Hankey in the final chapter, the prospect is bleak indeed. Reviewing the situation especially from the human angle, Lord Hankey concludes that the present time is peculiarly inopportune for launching new and highly controversial or complex schemes, owing to the open rift in the United Nations and elsewhere between the Western Powers and the U.S.S.R.; for the policy of the latter power is based, both in theory and in practice, on the necessity for the overthrow of capitalism. In spite of the future dangers of unrestricted atomic warfare, nations cannot be expected, Lord Hankey argues, to accept any plan to-day unless satisfied that it will work, that it will increase their security in peace, eliminate the atomic weapon in war, and diminish the probability of war. No scheme has yet been produced that offers a reasonable prospect of general acceptance, assured success and durability, or that does not contain features that are more likely to divide than to unite the nations.

In the circumstances, Lord Hankey concludes that the wisest course would be to suspend the work on atomic bomb control for a time to relieve the United Nations of this intractable question and to give them time to build up solidarity and to establish confidence among the nations. For the present, he believes that the question will be safer in the hands of the United States than of the United Nations, and the United States should be asked to seize any opportunity that offers, by bilateral or other methods, to reduce the difficulties and to prepare the way for an agreed settlement. In the meantime, he suggests as a token of good intention a ban on the use of atomic weapons in war, but that national research and development should not be forbidden.

These views Lord Hankey reiterated in the House of Lords; but they met with little support except from Lord Cherwell, who agreed on the value of disbanding the Atomic Energy Commission, but dissociated himself very strongly from the suggestion to ban the use of atomic bombs. Incidentally, Lord Cherwell's remark on Communists in scientific and engineering circles and the difficulty of making sure that they did not obtain all the information and knowledge which was being developed in any international research institution is of interest in view of subsequent developments, and Lord Cherwell went to the heart of the question in touching, like Mr. Middleton Murry, on the fundamental question of loyalties. Apart from Lord Perth's strong disagreement with Lord Hankey's premises, the debate was chiefly of interest for the clear statement it drew from Lord Pakenham of the present position of the Committee's examination of the Russian proposals and the reasons for regarding them as inadequate. Lord Pakenham said that there is clearly a strong desire among all the nations that atomic power should be controlled by international agreement, and a certain amount of agreement that technological control is possible. Nevertheless, progress is linked up with progress towards reconciliation with the U.S.S.R. generally, and even at that date Lord Pakenham admitted that the prospect of reducing the

differences between the Russian proposals and those of the Commission is less than it was a year ago.

Lord Pakenham stated frankly that some time limit must be set to this state of affairs, and that if the Government found that all advance was indefinitely, persistently and deliberately resisted, it would reconsider its whole attitude to the problem of atomic energy. Little more than a month after this statement, in view of Russian insistence on the retention of national sovereignty, the United Nations Atomic Control Committee appointed to draw up an international agreement for an atomic energy control board was adjourned indefinitely, a United States motion to dissolve the Committee being supported by Britain, Belgium, France and Canada. The technical committee of the Atomic Energy Commission has also reached deadlock, all but the Russian and Ukrainian members agreeing that further discussion of the Russian proposals is pointless.

When the Atomic Energy Commission reports this failure to the General Assembly of the United Nations, the members of the Assembly will have to decide whether or not to attempt to work out a collective scheme independent of the U.S.S.R. That will clearly have to be done outside the United Nations Organisation. The breakdown of these protracted discussions should make clear the need for realism for which both Lord Cherwell and Lord Hankey pleaded, and stress the plain fact that the so-called control urged by the U.S.S.R. is likely to be even more dangerous than no control at all. At the least the breakdown should stimulate clear thinking on the whole question of defence, including civil defence, which is indispensable to any effective system of national or of collective defence.

WATER REQUIREMENTS UNDER DESERT CONDITIONS

Physiology of Man in the Desert

By E. F. Adolph and Associates. (Monographs in the Physiological Sciences.) Pp. xiii+357. New York and London: Interscience Publishers, Inc., 1947.) 39*s*.

THE possibility that American troops might be required to fight in the desert caused a team of physiologists to go to the Colorado Desert in California during the summers of 1942 and 1943. Their efforts were mainly concentrated first on the effects of the environment and level of physical activity on the rate of sweating and on the water requirements of man, and secondly, on the physiological effects of water depletion.

As a result of field trials supported by experiments in a laboratory hot-room, these investigators were able to show that there is a linear relationship between the sweat-rate and the dry-bulb temperature. Men walking in the sun sweated at a rate of about 700 gm./hr. at 90° F. and at about 1,100 gm./hr. at 110° F. Walking in the shade at the same temperatures reduced the sweat-rates by about 300 gm./hr. Clothing was found to give a surprisingly high degree of protection against solar radiation, reducing the sweat-rate of men exposed to the sun by about 260 gm./hr.

On the basis of their results, the authors have produced charts and maps from which can be predicted the water requirements of men in different environments or in various parts of the world during the hottest month of the year. The value of these maps and charts is rather vitiated by the fact that the effects of both humidity and air movement have been neglected. In the desert, humidity admittedly is of little or no importance; but on the basis of some experiments in Florida it is erroneously concluded that it is also of little importance in the tropics. The important effects of air movement on the rate of sweating at high temperatures were not investigated.

The book is at its best on the effects of dehydration, and the marked effect of even moderate water deficits on temperature regulation is well brought out. Thirst was found to be a lagging guide to the degree of dehydration, and even with ample water most men when exposed to heat incurred some degree of dehydration. The oft-repeated assertion that it is best not to drink while exercising in the heat was found to be the reverse of the truth, nor was it possible to acclimatize men to dehydration. Voluntary dehydration did not effect any saving in water requirements as the sweat-rate remained virtually unaffected.

As the result of the studies on the rate of sweat loss and the effects of dehydration, practical measures are proposed for men stranded either in the desert or on rafts in tropical waters—predicaments that physiologically have much in common.

The book does not wholly live up to its title, and is primarily a record of the authors' own researches. A wide field was covered; but many relevant aspects of desert physiology are barely mentioned. The part played by salt, for example, is very inadequately described, and heat stroke and heat exhaustion, other than that caused by pure dehydration, are scarcely mentioned. There is much unnecessary repetition, and the book could be considerably improved by drastic condensation of several of the sections.

B. McARDLE

GATHERED NATURE STORIES

Nature's Own Zoo

By C. M. Beadnell. Pp. x+141+8 plates. (London: Watts and Co., Ltd., 1948.) 7*s*. 6*d*. net.

IN this attractive book Rear-Admiral Beadnell gathers together for boys and girls a series of true stories of some of the wonders of Nature, and of some remarkable and well-authenticated occurrences in the world of Nature. The whole book will be a source of joy and learning to the young, and even their elders will find much of interest in it. Who of us, for example, knew that the word 'penguin' is derived from the name 'pinwing', or 'pinion-wing', given centuries ago by the fishermen of Newfoundland to the great auk? The name has now been attached to the penguin, a bird unknown in the northern hemisphere.

On p. 34 an account is given of cormorants building their nests on a wrecked warship. Their nests were constructed of steel wire, and one nest was so heavy that two strong men were required to lift it. On p. 35 a raven's nest 5 ft. high is recorded, as being among the most bulky nests. The reviewer has in mind an eyrie of a golden eagle in a Scots pine which

has been used for very many years and is now perhaps 15 ft. in depth. There is a remarkable story (p. 73) of a Chinaman who was seen by the author to call swallows by a special whistle. The birds fearlessly alighted on him, and were fed on squashed bluebottles. The author afterwards saw the birds nesting inside the Chinaman's house.

It is gratifying to see the good work of the Society for the Protection of Birds in Vienna recorded. The autumn of 1931 was unusually cold, and swallows migrating south in September were unable to cross the Alps and, in the last stages of exhaustion, sought refuge in farms and villages around Vienna. Here they were collected and placed in cages, each holding perches for a thousand birds. On September 25, two thousand birds were transported by air over the Alps to Venice. On the following day no fewer than twenty-five thousand swallows were transported by air. The weather became yet more cold and stormy, so that air transport was impossible. Thirty-five thousand swallows were then sent to Venice by the night express, in a heated van, and on the following day, the weather having improved, yet another twenty-three thousand were transported by air, and released in warmth and sunshine.

The book is not all about birds. There is a fascinating account (p. 73) of how gossamer spiders literally set sail: these little creatures have dropped on ships sixty miles from the coast.

SETON GORDON

AUDIOVISUAL AIDS IN THE U.S. ARMED FORCES

Audiovisual Aids to Instruction

By William Exton, Jr. Pp. xiii+344. (New York and London: McGraw-Hill Book Co., Inc., 1947.) 4 dollars.

PRODUCED with a wealth of detail and lavishly illustrated, this book provides an important record of the war-time development of audiovisual aids for use in the training of U.S. naval personnel. The author, who played a responsible part in organising the U.S. naval programme for the production and distribution of audiovisual material, supplements his own account by contributions from naval colleagues in various special fields and from civilian experts who collaborated in the audiovisual programmes of the U.S. Armed Forces. Accounts of certain experiments and developments in Services other than the Navy are also included.

A notable feature of war-time training in both the British and the U.S. Armed Forces was the greatly increased attention paid to the use of visual and audiovisual methods as adjuncts to instruction. In both cases similar problems presented themselves: large numbers of recruits had quickly to be introduced to new patterns of behaviour and made proficient in new and at times intricate manipulative skills; instructors were relatively few, and not all of these were highly trained and experienced; there was a degree of urgency which called for intensive training methods and an imperative need for sound and sure results, since the cost of ineffective or inadequate instruction was counted in men's lives. In the U.S. Forces these problems were accentuated by a greater and even more rapid expansion than the British, while, as regards the U.S. Navy, one may presume that the majority of recruits would lack even that initial familiarity with matters of the sea to be expected in a maritime nation such as Great Britain.

In these circumstances audiovisual methods were obviously to be of powerful assistance not only in saving man-hours by the speeding-up of training, but also in helping to standardize instruction, in providing greatly needed assistance for the less highly qualified instructor, and as a quick and effective channel for the dissemination of training information as war-time developments brought about modifications in existing techniques and introduced new ones.

The U.S. Navy began the War with virtually nothing which could properly be called a training aid, apart from aids produced or acquired locally on the initiative of those conducting individual training activities. In the spring of 1941 the Navy Department possessed for training purposes some early 35-mm. training films produced in the 1920's, and a library of lantern slide collections covering some twenty subjects for use in the training of petty officers as electrician's mates, motor mechanics, etc. Both slides and films had been allowed to become obsolete. From this small beginning a highly complex organisation known as the Training Aids Development Center was developed for the planning, production, distribution and utilization of naval training aids. The story of the book under review is largely the story of the Center, of the aids it produced, the way it produced them and of the ways in which they were used.

The book is divided into five parts, of which Part 1 deals generally with the use and purpose of training aids and with the development of the Training Aids Development Center; the remaining sections deal separately with the various types of training aid, which are divided into those involving the use of a projector, 'graphic' training aids (defined as "two-dimensional representation not designed for projection"), sound training aids, and three-dimensional training aids.

The largest section (comprising more than one third of the book) and the one with most illustrations is that devoted to graphic training aids. It speaks well of the quality of the book as a whole, and of the work of the Training Aids Development Center, that of nearly 150 illustrations provided in this section only a handful fail to strike the eye as being thoroughly sound for their purpose in conception and execution, bearing in mind, too, that in most cases the originals had the advantage of colour. The examples of mechanical illustration, particularly, present a standard of accurate and functional artistry which can leave no doubt as to their high training value. This section contains a useful account of the 'silk-screen' process, and an interesting discussion of the role of the 'creative' artist in the training aid field. It is tantalizing to find that, for obvious reasons, reproduction is not included of the Navy's most ambitious pictorial aid—a schematic diagram, measuring 100 in. by 40 in. and incorporating nineteen colours, of the Westinghouse pneumatic controls for steering a destroyer escort vessel.

The lay-out of the book tends towards a certain amount of repetition, as does also the fact that contributions on closely related themes are drawn from more than one pen; nor is the American writer subject as we are to the salutary discipline of paper scarcity. There is too, perhaps, an undue eagerness to be comprehensive down to the point of minute

detail, and an over-elaborate concern for classification. These are faults of enthusiasm, and the book is noteworthy for the sense of serious purpose evident in all contributions as well as for a clear and realistic conception of the limitations as well as the advantages of audiovisual methods. Only in one short chapter, on the "Utilisation of Radio Recordings", are claims advanced for the medium which one could not readily allow. It is interesting to note that little attention appears to have been paid in the U.S. Armed Forces to the development of the 'visual unit' (a set of films, film strip, charts, etc., integrated for the treatment of a single topic); and that the film strip projector, such a popular training adjunct in the British Forces, does not appear to have been widely used.

Although a thorough evaluation is made of the effects of audiovisual methods on war-time training in the Forces, the record, very wisely, has been allowed to speak for itself, and civilian readers are left to draw for themselves the necessary inferences as to how civilian instruction may best benefit from the lessons of war-time military experience. The problems of the civilian teacher are in many ways very different from those of the war-time military instructor. The accent moves from high pressure and standardized instruction, often in fairly narrow manipulative skills, to a type of work in which the use of mass-produced visual or audiovisual aids requires careful and judicious control by the individual teacher, and must often be supplemented by his own personal contribution. It must be remembered, too, that economic considerations will often outweigh all others. A single three-dimensional aid for use in anti-submarine work was established by the U.S. Navy at a cost of more than a million dollars—surely the most expensive training aid ever devised. This apparatus, fully described in the text, more than justified its cost; but its undertaking provides an index of the degree to which financial considerations are subordinate to the urgencies of war.

Within the different context of civilian life, however, many useful applications can be made. The continued development of audiovisual methods in our civilian schools and industrial training organisations can be of immense benefit to both technical and general education. This careful and balanced record of war-time experience in the U.S. Armed Forces will interest all who are convinced of the importance of such aids in the teaching process.

ERIC LOWE

GEOGRAPHICAL APPROACH TO THE HISTORY OF THE BRITISH ISLES

Some Aspects of British Civilization

By Prof. H. J. Fleure. (The Frazer Lecture, 1947.) Pp. 32. (Oxford: Clarendon Press; London: Oxford University Press, 1948.) 2*s*. 6*d*. net.

MUCH attention has been given in recent years to the geographical background of history, and particularly of British history, and it is well realized how strong an influence the geography of the British Isles has had on their story from primitive times onwards. It may be, however, that the influence of geographical features in retaining continuity of development in each region from time immemorial has not always been emphasized sufficiently. This is the theme that Prof. Fleure has taken for his Frazer Lecture, wishing, as he says, "to bring out in some measure the deep roots of our country's life in a far off past and the continuity from those times to the present".

Prof. Fleure tackles the problem in two parts, dealing first with the three main routes of ingress into Britain—the North Sea, Channel and Atlantic—and secondly, with the divergencies within the country between Highland, Fall and Lowland Zones. In the first part he follows closely Sir Cyril Fox, Margaret Dunlop and others, who have traced the archæological invasions from neolithic times onwards to their European and Mediterranean sources, and has little new to add, albeit at times giving a variant slant to the picture. This is the less interesting portion of his essay, for the story is too long for anything more than a cursory sketch to be possible within the compass of a few pages, and much that is of great interest, especially about immigrations after the Bronze Age, is not dealt with by him at all. One wonders, indeed, how intelligible such a brief sketch will be to anyone not already conversant with the full story and ignorant of the archæological finds on which the story is based.

In the second portion, Prof. Fleure's touch is surer and happier. He traces the conservatism of the Highland moorland areas from prehistoric times onwards, leading to survivals of language and customs. These areas, he says, have been fully, though sparsely, inhabited from earliest times. In contrast in the Fall Zones there are, he maintains, few traces of prehistoric life apart from Iron Age camps; the first important development did not come until after medieval clearance of the woodland and foundation of castle towns and abbeys to guard against raids of the hill people; and major development only came in the industrializing era. But is this really true? Are traces of prehistoric settlement—not to mention development in Roman times—so sparse in the Fall Zones (Cheshire and Shropshire, for example) as Prof. Fleure suggests, and if so, may it not be because less research has taken place there than in Lowland Britain?

Coming lastly to the Lowland Zone itself, Prof. Fleure emphasizes—as did Sir Cyril Fox—the importance of the Jurassic scarp, and differentiates between the Lowlands west and north-west of that line, where dense oak woods led to late development, and those in south-east England, where there has been repeated overlaying of old cultural features by new.

One of Prof. Fleure's main theses is that much more research and careful compilation of distribution maps of cultural features (he mentions specially house-types—timber-framed, brick, stone, and mixtures of two or more) are required before the zonal story he sketches can be more fully delineated. There is no doubt that many interested in medieval and later archæology are now fully alive to this need, and we may hope, therefore, that Prof. Fleure's wishes will be realized. In particular, the movement for the development of folk museums and the study of folk culture by regions which has grown apace in Britain in recent years will undoubtedly be a good influence in this direction. Students of prehistory and early history have already shown the way, and when the later picture has been sketched the full canvas can be completed.

D. B. HARDEN

Industrial Experimentation

By K. A. Brownlee. (Ministry of Supply: Directorate of Royal Ordnance Factories, Explosives.) Third edition. Pp. 168. (London: H.M. Stationery Office, 1948.) 3*s.* net.

THE first edition of this work was reviewed in *Nature* of November 16, 1946, p. 687. In the subsequent two editions a considerable amount of new material has been added, including references to a wide range of theoretical and practical sources. A valuable addition is a short section on randomization, with a table of random sampling numbers.

In the third edition a chapter dealing with balanced incomplete block and Youden square designs has been added. This, together with the discussion of Latin squares in the chapters devoted to the analysis of variance, seems to render superfluous the sections on these designs which were added to the introduction in the second edition.

A chapter on confounding, with factors at two, three, and four levels, has been added. Other new material includes sections on missing values, Græco-Latin squares, and the assumptions underlying the analysis of variance. The distinction made in the first edition between 'large' and 'small' sample methods for comparison of two means has been eliminated, only the exact formula now being given. Unfortunately, most of the criticisms of the first edition made by Mr. D. J. Finney in the review referred to above still hold good. The exact formula for residual variance about a regression line has been added, though in a separate section, some pages after the approximate formula previously given. The section on the analysis of variance still gives far too little attention to the theory underlying the methods so extensively illustrated.

It is unfortunate that the author makes no difference in notation between the population and estimated variance. This is presumably intended as a simplification; actually it often has the opposite effect. The introduction of new material with little amendment of the old has rendered the plan of the book somewhat confused, and heightened the impression that too much is being attempted in too small a space.

The book is potentially of great value, but is at present in need of a complete redrafting. This might well be accompanied by a considerable expansion, making it possible to introduce rather more of the underlying theory than can be included in a book of the present size. M. R. SAMPFORD

Science Advances

By J. B. S. Haldane. Pp. 254. (London: George Allen and Unwin, Ltd., 1947.) 10*s.* 6*d.* net.

IT is not easy to discern the relevance of the title to the series of essays which Prof. J. B. S. Haldane has collected in this book. They cover a wide field. Some rather scrappy biographical sketches of Newton, Archimedes, Copernicus, Landsteiner, de Geer, Eddington and others are followed by sets of essays on animals and plants, human physiology and evolution, medicine, hygiene, inventions, on Soviet science and Nazi science, and an article on human life and death at high pressures which appeared in *Nature*. They touch on such subjects as bird migration, instinct, vernalization, afforestation, the electron microscope, immunization, overcrowding, microfilms, and fisheries, and in many of them Prof. Haldane shows to the full his talent as an expositor of a high order. But it is difficult to believe that Prof. Haldane is really concerned first and foremost with that task of explaining science to the public which he believes is the responsibility of men of science in a democracy. His first concern is not to advance science but to advance communism, and one suspects that communism and not science should be the title word.

We need, and need badly, expositors with Prof. Haldane's gifts, and in this book he says frankly much that needs to be said and attacks abuses that demand redress. But it is time that protest was made against the view that subjective exposition can advance the cause of science, and Prof. Haldane's carelessness in this respect may well alienate the support of those whose help is badly needed. Nor does it help the advance of science to attach radical or political labels to it. R. BRIGHTMAN

Pastures and Pasture Research

By C. M. Donald. Second edition. Pp. 117. (Sydney: University of Sydney, 1946.) n.p.

GRASSLAND is still the chief raw material of stock farming, and therefore a full understanding of its problems is important in the basic industry of animal food supply. Mr. C. M. Donald held for two years the Powlett Scholarship of the University of Sydney, and visited Britain, the United States and New Zealand. He has summarized the experience thus gained with a view to its application in problems of Australian grassland. The result is a small volume dealing with scientific principles of pasture management. It discusses the role of pastures in land utilization, pasture composition and seeds mixtures, species and strains of pasture plants, pasture management, the nutritive value of pastures, and the technique of experimentation as applied to grassland. The general agricultural reader might perhaps be most interested in the development of Svalof strains of late red clover resistant to *Sclerotinia* stem-rot, and in the application of the Gentner ultra-violet test for purity of perennial ryegrass. A chemical test with picric acid for the purity of wild white clover promises to have more practical significance than the ultra-violet test. The booklet is well illustrated by diagrams and photographs, and would be useful to workers in any region who require a succinct résumé of modern pasture research.

JOHN GRAINGER

Smithsonian Elliptic Functions Tables

Prepared by G. W. and R. M. Spenceley. (Smithsonian Miscellaneous Collections, Vol. 109: Publication 3863.) Pp. iv+366. (Washington, D.C.: Smithsonian Institution, 1947.) n.p.

THESE are 12-place tables of the three classical Jacobian functions $\mathrm{sn}\,u$, $\mathrm{cn}\,u$, $\mathrm{dn}\,u$, the amplitude φ, the function $E(u)$, and the two normalized theta functions $\vartheta_c(K-u)$, $\vartheta_n(u)$. The parameter is the modular angle θ, and the explicit variable is not u but $90u/K$, that is, u measured in terms of an 'elliptic degree' obtained by dividing the quarter period into ninety parts; the entries are for $\theta = 1°(1°)89°$, $90u/K = 0(1)90$. The volume is scrupulously accurate, but it is almost useless in the absence of guidance on interpolation. Linear interpolation in these tables is more troublesome and not more accurate than quadratic interpolation in Milne-Thomson's five-place tables. Interpolation of higher order is much too laborious to be undertaken without an initial estimate of the work involved in relation to the accuracy to be attained.

FISH FARMING IN THE MIDDLE AND FAR EAST

By Dr. C. F. HICKLING
Fisheries Adviser, Colonial Office

FISH culture covers a wide field of activities by which the yield of fish from a given area of water can be increased by artificial means. It ranges from the stocking of natural waters with desirable species, and the encouragement of favourable environmental factors for their growth, accompanied perhaps by the elimination of undesirable species, to the construction of special ponds in which all the operations of animal husbandry are practised. It is with the latter aspect of fish culture, the true fish farming, that this article is concerned; although it is no more possible to give a complete account of fish farming than of any other type of farming in a single short article.

The yields obtained in fish farming are, of course, much greater than those from natural waters. Below are given some examples of yields of edible fish per acre per annum for certain natural waters, and for certain examples of fish farming.

Natural waters	Per acre per annum
Lake Victoria[17]	1·4 lb.
Lake Bardaweel, Egypt[2]	4
North Sea[1]	15
Lake Rukwa, Tanganyika Territory[3]	16
Lake Tiberias[1]	22·5
Lake Brullos, Egypt[2]	52
Lake Qarun, Egypt[2]	93
Lake Maryut, Egypt[2]	135
Lake Edku, Egypt[2]	255

Fish farms	Per acre per annum
United States, unfertilized[4]	40–150 lb.
United States, fertilized	200–400
Central Europe	168
Jugoslavia	327
Philippines[15]	450–900
Palestine[5]	1200
Hong Kong[6]	2000–4000
Malaya[7]	3500
South China[8]	4000

It is true that the high yield of fish farms is got sometimes at considerable outlay in capital cost and recurrent costs, including the cost of fodder and fertilizer; but the exploitation of natural fisheries may also involve considerable capital and recurrent costs. Fishing craft and gear have to be replaced frequently, but well-sited fish-ponds have stood for centuries in China.

Fish-ponds may be either freshwater or salt-water. Salt-water ponds are built or excavated in salt marshes, or in mangrove or nipah swamp, either facing the sea or on the shores of estuaries. They are sited so that the water in them can be renewed or emptied by opening sluices at spring tides. Salt-water fish-ponds reach their greatest development in the Philippines and the Netherlands East Indies. In the latter, the experts have contemplated pumping water into the fish-ponds and so allowing the ponds to be sited independently of tide-levels. Their experience leads them to believe that the fish-ponds are profitable enough to bear the cost of pumping. Usually, in these salt-water fish-ponds the fish are not artificially fed, nor are the ponds fertilized; but, since they are usually on rich volcanic soil, the natural growth of plants suffices to give a good yield of fish which feed on them. Yet I am told that the Japanese fed the fish in their marine fish-ponds on Formosa, getting high yields, and the Netherlands East Indies authorities have experimented with fertilizers.

Freshwater fish-ponds are usually built or excavated in marshy ground, or on land of marginal use for agriculture. They may, in fact, be regarded as a step in the reclamation of such land. The marine fish-ponds of Java, also, are a stage in the extension of paddy cultivation. Such marine fish-ponds tend to become less and less saline, until they will grow rice; the seaward belt is then added to by taking in more mangrove, or by bunding in the silt which tends to form to the seaward side of such fish-ponds. Even where they are constructed on potential agricultural land, they do not necessarily compete with its agricultural use. They may be used to grow alternative water crops, such as water chestnut, and watercress and arrowhead for human consumption, or water lilies and water hyacinth for pig food. They may be used to grow rice or other irrigated crops. The accompanying photograph shows a corner of a fish-pond at Tai Leong, in the Pearl River Delta of China, in which rice is growing. In this area alternate crops of paddy and fish may be taken, the paddy crop from February to June or July, and the fish crop from July to December and January. Fish-ponds fit in particularly well with a system of peasant small-holdings, as they can be run concurrently with a number of other activities, such as vegetable gardens and pig- and duck-raising.

Fish-ponds must, of course, be situated where they can be kept filled with water, and in lands where water is scarce there may be competition as between fish-ponds and irrigated crops. But Bertram[8] points out that evaporation from a water surface is not necessarily greater than from a growing irrigated plant crop, and that fish must be regarded simply as an alternative crop, to be judged on its merits, having regard to current demand for food, whether animal or vegetable.

Some idea of the scale on which fish farming is carried on in the Far East may be got from Furnivall[9], who estimated that there were some 200,000 acres of marine fish-ponds and at least 100,000 acres of freshwater fish-ponds in the Netherlands East Indies. Hoffmann[8] estimated that in six districts of the Kwangtung Province of China alone there were some 200,000 acres of fish-ponds. Frey[15] states that, before the recent War, there were 60,000 hectares of marine fish-ponds in the Philippines.

The size both of the fish farms and of the individual ponds varies greatly. In Palestine, the individual fish farm may be more than 100 acres, with ponds as large as 15 acres or more. In the marine fish-ponds of Java, the individual ponds may be 6–7 acres in extent, and in the Philippines 5 acres. In Hong Kong the largest ponds I saw had an area of 10 acres on a farm of more than 60 acres. A few of the ponds I saw in the Pearl River Delta had an area of 3 acres, and at Shuihing on the West River, of 7 acres. But, in the Far East, most of the fish-ponds are small, of a size less than an acre. The depth is usually 3–5 ft.

In freshwater fish-ponds, the renewal of the water may depend simply on rainfall and local drainage and seepage. Where running water is available, it may be diverted into a channel, sometimes of considerable length, from which the ponds are fed by sluices. A cruder but effective arrangement is to put up a temporary dam in a nearby stream or ditch, whereby the water-level may be raised to the point when it will flow into the fish-ponds. In the Pearl River Delta, and to some extent in Hong Kong and Singapore, the water may be renewed by the action of the tides. When the rivers are in full flow after

A FISH-POND AT TAI LEONG, PEARL RIVER DELTA

rains, the rising tide coming up the rivers may cause the level of the river to rise by many feet, and as the surface water, at all events, will be fresh, sluices are opened, or channels cut, to take the surface water into the ponds.

Where the ponds are embanked, they can be emptied through sluices; but, where they are excavated, they cannot be emptied by gravity. They may never be emptied, the bottom being cleaned by scraping with special long-handled scoops, or, in the case of small ponds, they may be emptied by treadle pumps. Where the ponds are never emptied, the water is freed from predatory fish and other harmful organisms by poisoning the water between each crop of fish.

Species of Fish Used

The most important species cultivated in marine fish-ponds is the salmon-herring, or milk-fish, *Chanos chanos* Forsk.[13,14,15]. But mullet also flourish in marine fish-ponds, and prawns, which breed freely in the ponds, are a valuable catch-crop. In Java, the aquarium escape *Tilapia mossambica*, an East African species, has been cultivated with success in the marine fish-ponds during and since the War, when the disruption of communications has prevented stocking with the fry of the *Chanos*. But *Chanos* also is a very adaptable species, which can easily be acclimatized so as to flourish in fresh water; it is being stocked in the inland waters of India[16].

In the freshwater fish-ponds, some of or all the following species are stocked together in the same ponds.

PALESTINE	JAVA[9]
Common carp (*Cyprinus carpio* Linn.)	Common carp
? Tench (*Tinca tinca* Linn.)	Gourami (*Osphronemus olfax* Blkr.)
	Tawes (*Puntius javanicus* Blkr.)
	Nilem (*Osteochilus hasselti* C.V.)

HONG KONG[9]	CHINA[11]
Common carp	Common carp
Grass carp (*Ctenopharyngodon idellus* Cuv. and Val.)	Grass carp
Silver carp (*Hypophthalmichthys molitrix* Cuv. and Val.)	Silver carp
Big head (*Aristichthys nobilis* Richardson)	Big head
Black carp (*Mylopharyngodon æthiops* Basilewsky)	Black carp
Mud carp (*Cirrhina mollitorella* Cuv. and Val.)	Mud carp
Grey mullet (*Mugil cephalus* Linn.)	

Where many species are stocked together, they are species of complementary feeding habits, and so chosen that all the available food in the pond, whether natural or supplied by the fish-farmer, is fully used.

In the Javanese culture, the Gourami is a grass and vegetable feeder, the Nilem is a macroplanktonic feeder, the Tawes a bottom feeder and the carp a bottom feeder and general scavenger.

In the Chinese culture, the grass carp is a vegetable feeder, the silver carp a microplanktonic feeder, the big head a macroplanktonic feeder, the mud carp a bottom feeder, the common carp a general scavenger and the black carp a feeder on molluscs and crustaceans. In Hong Kong the grey mullet is stocked in very large numbers in partial substitution for the mud carp.

The rate of stocking, and the ratio of different species used, varies according to the productivity of the pond and the judgment of the farmer. But the grass carp and the mud carp are usually the chief species. As an average of a number of ponds seen by myself, and quoted by Lin[9], the following is the composition of the communities in Chinese ponds per acre.

Grass carp	530
Big head	315
Silver carp	260
Common carp	375
Black carp	35
Mud carp	2125
	3640

This is a far higher rate of stocking than in Palestine, where the fattening ponds are stocked at a rate of about 1,000 fish per acre. The higher rate of stocking is probably due largely to the fact that many different species of complementary habits of life are stocked in the Far Eastern technique. The ratio of yield is about the same also, namely, about 1,200 lb. per acre per annum in Palestine and about 3,500 lb. per acre per annum in the Far East, showing that the rate of growth is just as good in spite of the heavier stocking.

It should be stressed again, however, that there is very great variation in the rate of stocking. For example, on a fish farm in the Pearl River Delta, one pond was stocked at the rate of 2,820 fish per acre, whereas a second pond, which had had for many years the benefit of a buffalo wallow on its banks, and was therefore much richer in plankton, was stocked at the rate of 3,720 fish per acre. Its yield was estimated at a rate of more than 5,000 lb. per acre per annum.

Feeding

The carp in Palestine are artificially fed, the ideal food being lupin seeds, though oil cake, such as cotton seed and peanut cake, have also been used, especially during the War. The growth of plankton is also stimulated by the application of farmyard manure and compost.

In the marine fish-ponds, the natural growth of algæ and other aquatic vegetation is usually the sole source of food[13,14,15].

In the Far East, the ponds are manured to produce a rich plankton; but, for the grass carp, large quantities of cut grass which may be specially grown

for the purpose, and other vegetable matter are thrown into a special feeding enclosure, which takes the form of a big ring of twisted ratans or a rectangle of floating bamboos. This prevents the cut herbage from being scattered over the pond. In addition to this, other food is provided. It may be rice-bran or copra waste, silkworms or silkworm fæces, peanut cake, and even termites.

According to Chen[11], the grass carp feeds upon the cut herbage, and also on the artificial feeding materials supplied, while the big head and silver carp feed on the plankton generated by the manuring. The common carp and mud carp feed upon the artificial feeding materials, and the mud carp also on the bottom mud, enriched by the plankton and also by the fæces of all the other fish. The fæces of the grass carp consist of partly digested and finely divided vegetable matter; this also feeds the big head and silver carp. The few black carp eat the water snails, and, where these are abundant, extra black carp will be stocked.

Thus a very complete use is made of all natural and artificial food in the pond, and this is the reason (together with a high and comparatively uniform temperature) for the astonishing yields of these ponds. The expert fish culturist judges the productivity of his ponds by the colour and density of the plankton, and will add sufficient manure to maintain the optimum conditions. At the same time he will judge the acidity of the water by its taste.

Stocking and Breeding

Few of the species used in these techniques of fish culture are bred in the ponds. Indeed, the common carp, the Gourami, the Tawes and Nilem are the only fish which will so breed. In all other species, breeding will only take place in the wild, so that there is an extensive ancillary fry industry to supply the fish-ponds.

In the marine fish-ponds the *Chanos chanos* has never been known to spawn. The fry of this fish, and of the mullet, must be caught on the beaches and in the estuaries, and transplanted into the fattening ponds. The very valuable Chinese carps will only breed in certain rivers, of which the West River (Si Kiang) is the most important. In these rivers fry is caught in hundreds of millions in nets of ramie cloth spread out on stakes along the banks. The fry is sorted with immense skill, by passing through graded sieves, and by using the different oxygen requirements of the various species. For example, mixed fry may be allowed to stand in a limited amount of water until all are close to the surface in a struggle to get oxygen. Then a carefully judged quantity of fresh oxygenated water is added; at once those fry which need less oxygen leave the surface layer, and those remaining are skimmed off. In this way up to 90 per cent purity can be obtained. There are only a few fry culturists experienced enough to do this sorting accurately (Lin[6]).

The very young fry, after sorting, are reared in special ponds, manured with cow dung and compost; they feed upon the plankton generated. When they grow larger, they may be fed with Australian flour shaken through a coarse cloth; for the young grass carp a small duckweed, *Wolffia arrhiza*, is specially grown. Finally, they are reared to the stage when they can be transported, from south China to Singapore, Java, Formosa and other markets. Mr. Le Mare, director of fisheries, Federation of Malaya, has recently introduced fry transport by air with success, and by this agency these valuable fry may, in the future, find a much wider market than at present.

The common carp will breed in captivity, and mature fish are placed in special spawning ponds, or in special enclosures in the fish-ponds. They are provided with bundles of brushwood on which to deposit the spawn, or with special frames containing teased-out coconut fibre. The frames, when covered with spawn, are removed and placed in hatching ponds.

The Gourami is also provided with similar frames, in which it builds its nest. In the case of the Nilem, small pools are connected with the main pond. The Nilem spawns at the entrance to these pools, so that the eggs are carried by a gentle current on to the gravelly bed of the pools, where they soon hatch (Furnivall[9]).

Fish-ponds and Disease

Birtwistle[7] states that, in the carp ponds of Singapore, mosquitoes are not produced if the ponds are in full cultivation, and Bertram[5] had the same experience in Palestine. Sunier[13] showed that the marine fish-ponds of Java were dangerous breeders of malaria-carrying mosquitoes; but, more recently, Overbeek and Stoker[14] have shown how these marine fish-ponds, and also fresh water fish-ponds, have been made safe by appropriate clearance and drainage measures. In China I was told that the fish in the ponds deal effectively with mosquito larvæ. The chief prerequisite is that the pond shall be free of masses of weed, whether fixed or floating, in which mosquito larvæ can develop protected from the attacks of fish. Pielou[16] in Northern Rhodesia showed that the only specimens of the malaria-carrying *A. gambiæ* and *A. funestus* found in the main dam at Chilanga, Northern Rhodesia, were respectively in a mat of floating debris, and among the semi-submerged grass at the margin of the dam, which is stocked with *Tilapia Kafuensis* and bluegill sunfish, *Lepomis macrochira*. On the other hand, in pools without fish, and in seepage ditches and puddles, these mosquitoes were frequent. Irvine[12] states that *Tilapias* are effective against mosquitoes, and experience has shown that they are also excellent pond-fish. I did not hear of bilharzia being propagated by fish-ponds; but the inclusion in the pond community of a few snail-eating fish, as in China, would guard against this danger.

In China, liver-fluke disease is conveyed by the eating of fish reared in ponds fertilized by raw night-soil. The remedy for this would be not to use night-soil as a manure for the ponds, or to use composted night-soil only, in which the heat of composting will have destroyed the young stages of the flukes.

Conclusion

The significance of fish farming as a technique does not seem to be widely understood, except in India, where great efforts are being made to propagate it. There are few countries, certainly in the tropics, which are so fortunately placed as to be able to get adequate supplies of fish from natural sources. Moreover, populations are growing, and industrial developments are calling for a higher standard of nutrition. Protein shortage has always been the bane of most tropical populations and, for a number of reasons, meat will not wholly supply the deficit.

It is the policy of the Colonial Office to develop fish resources everywhere, and there is a vast field of work, in exploring and in improving, by experiment and precept, the natural fisheries, both freshwater and marine. But the product of the natural fisheries can be powerfully supplemented by the product of fish-ponds, especially where difficulties of transport and preservation stand in the way of meeting the requirements of the populations by fish from natural fisheries. There are big areas of marshy land, particularly in Africa and in the West Indies, which could be developed for fish farming, and fish farming could also be introduced wherever there is well-watered land undeveloped, or even in developed land as part of a mixed culture. Moreover, along the coasts there are many areas where marine fish-ponds could be laid out. The aim should be to make each community self-supporting for fish, or, still better, with a surplus to pass into the common supply.

The Colonial Office therefore plans to set up a research institute, on the scale of a first-class agricultural station, to study the fundamental processes underlying the high yields of fish-ponds, to study the genetics of fish and the physiology of breeding, and to get statistically controlled data of yields under a great variety of treatments. Here, also, fish culturists would be trained under experts.

The results of these fundamental researches would be applied, suitably modified, in each Colonial territory, and with communities of fish, preferably native fishes, best adapted to each.

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MAX PLANCK MEMORIAL CEREMONY AT GÖTTINGEN

APRIL 23 of this year was the ninetieth anniversary of Max Planck's birth, and it had been the hope of his colleagues and admirers that the day might be the occasion of a simple festivity at which they could express their admiration and affection in the presence of the man in person. His death last October having prevented the realization of this wish, the Max-Planck-Gesellschaft zur Förderung der Wissenschaften (see later), the University of Göttingen, the Akademie der Wissenschaften of Göttingen and the Deutsche Physikalische Gesellschaft decided to celebrate the day by ceremonies devoted to the memory of Max Planck. Accordingly, on a bright spring day in the beautiful town of Göttingen, which fortunately is untouched by the hand of war, the character and achievements of the great man were fittingly celebrated by tributes in which appreciation of his scientific work and veneration for his personal qualities were equally balanced.

The first ceremony took place at 9 o'clock in the morning at his grave, marked by a simple stone, when wreaths were solemnly deposited by some of the foremost men of science in Germany, representing German universities, scientific societies and other bodies, and by representatives of certain scientific institutions of other lands. The British representatives were Sir Charles Darwin, representing the Royal Society; Prof. E. N. da C. Andrade, supported by Sir Robert Watson-Watt, representing the University of London; and Dr. B. K. Blount, representing the Research Branch of the Central Control Commission at Göttingen. Dr. Nordstrom represented the National Academy of Sciences of the United States and Prof. Otto Hahn laid a wreath on behalf of the Royal Swedish Academy. Many of the representatives spoke brief words of admiration of the great scientist. The occasion was deeply impressive. After a short interval the representatives proceeded to the Aula (Great Hall) of the University, where the main ceremony took place.

This was divided into two parts. The first consisted of brief addresses, delivered respectively by Prof. Otto Hahn, president of the Max-Planck-Gesellschaft zur Förderung der Wissenschaften; Prof. Hans Stille, vice-president of the Deutsche Akademie der Wissenschaften of Berlin, with which Planck was for so long prominently associated; Sir Charles Darwin, representing the Royal Society, of which Max Planck was a foreign member; and Prof. Hermann Dersch, representing the University of Berlin. A tribute from the Washington Academy of Sciences, written by Albert Einstein, was read by Prof. Hahn. The second part comprised three speeches in memory of Max Planck. Prof. Max von Laue spoke of the history, particularly the early history, of Planck's scientific work, laying stress on his handling of thermodynamic problems; Prof. Werner Heisenberg spoke particularly of the later developments of the quantum theory and of Planck's interest in recent work; Prof. Richard Becker dealt rather with the philosophical implications of Planck's work and with his human qualities. He introduced records of Max Planck's voice with striking effect. Throughout the ceremony, at which a large audience attended, the deep sincerity and controlled emotion of the speakers were evident, and the atmosphere was sustained by a simple and admirably chosen programme of music carried out by Karl Klinger, violinist, and Raimar Dahlgrün at the piano. Bach introduced the meeting, Brahms came between the two parts, and the last movement of Beethoven's Kreutzer sonata concluded the ceremony.

In the evening of the day of the ceremony an informal party ("Zwangloses Beisammensein") was given in a hall of the extensive premises of the Aerodynamisches Versuchsanstalt*, formerly devoted to aeronautical research for the German Government and now in the hands of the Research Branch of the Central Control Commission under Dr. B. K. Blount, to whose co-operation the party was due and to whose friendly efficiency the British visitors are much indebted. At this party various prominent German figures were present, including Otto Hahn, Lise Meitner, Max von Laue, Werner Heisenberg, Ludwig Prandtl, R. W. Pohl, R. Becker, Erwin Meyer, E. Gruneisen, W. Meissner, J. Mattauch,

* Still known as 'AVA', although the first 'A' now indicates 'Allgemeines'.

W. Koesters and others of world-wide repute, as well as the British and American representatives. It is pleasant to be able to record that the proceedings were without constraint and of the friendliest, so that it might have been a gathering of scientific friends at a German university before the First World War.

Many of those present for the ceremony stayed at Göttingen for a further day or two, and the occasion was one of much discussion of the newly founded Max-Planck-Gesellschaft, under which title the old Kaiser-Wilhelm-Gesellschaft has been reconstituted. This comprises thirty-four research institutes in the British and American Zones, of which six are at Göttingen. The president is Otto Hahn, the discoverer of uranium fission, and other Göttingen notabilities prominently associated with the Society are von Laue, Heisenberg and Windaus. The head of the management (Geschäftsführender Vorstand) is Dr. Ernst Telschow, who was a prominent figure at the discussions that took place. The Max Planck Institute for Physics under Werner Heisenberg is accommodated in a fine building of the AVA, and is largely concerned with cosmic rays, both from the theoretical and experimental points of view, with the particular aim of elucidating the reciprocal transformations of waves and particles. Superconductivity and astrophysics will also be prominent subjects of study. Theoretical work is in full swing, but so far it has not proved possible to erect the refrigerating apparatus necessary for experimental work on superconductivity. Much apparatus for cosmic ray research is already working.

Active work on the more theoretical aspects of aerodynamics and hydrodynamics is proceeding in the Max-Planck-Institut für Strömungsforschung under Walter Tollmien, who has succeeded Prandtl, still a prominent figure, though retired on account of age. In the same Institute much work is being carried out on friction. There are also Institutes for Brain Physiology, Medicine, Scientific Instruments and Physical Chemistry.

There are many difficulties in building up scientific work at Göttingen, but how they compare with those in Britain would be a matter for detailed study, possibly not without controversy. However, what is incontrovertible is that the spirit is excellent and that there is every hope that Göttingen will soon be once more an active source of scientific results of the highest importance. Much credit in this connexion is due to Dr. B. K. Blount, of the Control Commission, who has carried out a difficult task with equal tact and efficiency.

E. N. da C. Andrade

LYON PLAYFAIR AND TECHNICAL EDUCATION IN BRITAIN

By W. H. G. ARMYTAGE
University of Sheffield

THIS year marks the fiftieth anniversary of the death on May 29 of Lyon Playfair, chemist and statesman. In both roles he made a name that lives to-day, for as a chemist he played a large part in the discovery of the nitroprussides and (with Bunsen) made a valuable report on the gases evolved in iron furnaces; while as a statesman he urged, by every means in his power, the adoption of the new scientific knowledge and techniques. In both spheres he fulfilled the role of one of the chief architects of the system of technical education in Great Britain as it exists to-day.

The whole logic of Playfair's career lay in this. He was trained as a medical man; but his subsequent studies under, and friendship with, Liebig made him alive to the necessity of applying organic chemistry to other fields, as Liebig had applied it to agriculture. By the time he was twenty-four he had established such a reputation for himself that, when he wished to take up a professorship in Toronto, the Prime Minister personally requested him to stay in England. For his practical bent had been appreciated, and soon afterwards he was a professor at the School of Mines in Jermyn Street, exploring the possibilities of coal for steam navigation, and the causes of potato disease in Ireland. In view of all this activity, it was not surprising that he was elected to fellowship of the Royal Society when he was thirty.

The main event of Playfair's life was the Great Exhibition of 1851. The idea was Prince Albert's. Its projection was in the hands of a Royal Commission, and at times the Royal Commission clashed with Prince Albert's executive committee. Playfair was appointed as a liaison officer between the two bodies, and his grasp of the situation was responsible for the organisation of the juries being delegated to him. This work made his name. He was made a C.B. and given a place in the household of the Prince Consort. Henceforth, as the later exhibitions of 1862 and 1875 show, he was to be closely identified with this kind of work.

The Prince Consort was anxious to devote the profits of the Great Exhibition (£186,436) to the practical application of science and art to productive industry. This scheme was vigorously supported by Playfair; so vigorously, in fact, that his vehemence on the subject caused him to be suspected of secularism. Eventually, when the report of the commissioners was published, it was decided to supplement the profits by a parliamentary grant of £150,000, and to purchase the three estates of Gore House (21 acres), Villiers (48 acres) and Harrington (17 acres). On this land, from now on called South Kensington, the Prince Consort intended to concentrate all the existing institutions already in existence. So ambitious a project, however, was not immediately practicable, and a start was made with the foundation of the Royal College of Science.

The real result of the Great Exhibition from our point of view was the establishment of a government department to encourage technical education, and it was, significantly enough, originally constituted under the Board of Trade as a dual department. Playfair was appointed as first secretary of the Science Department in 1853, and later, when the Art Department merged with the Science Department and came under the Committee of the Privy Council, he was made responsible for the united body. He now held a position *vis-à-vis* technical instruction as important as James Kay-Shuttleworth had held in the world of elementary education. But unfortunately for technical education, the Crimean War proved a serious handicap to his efforts. For not only were extensive grants to the new department impossible, but also Playfair's time was monopolized by the Government in experiment. The importance of his position was not lost on him, and he wrote a telling pamphlet called "Industrial Education on the Continent", demanding an official inquiry on the

subject. It was the overture to a theme that he was never too tired to expound, and from now on the correspondence column of *The Times* was a convenient platform on which he could exhibit his ideas.

When Playfair was forty years of age he was elected to the professorship of chemistry at Edinburgh. A fortunate marriage the year before made it unnecessary for him to work for his living as a Civil Servant, and it enabled him to build up a teaching laboratory. To this latter purpose he devoted all his professorial income during his first year, and a large part of it during succeeding years. So it is not surprising that when the 1867 Reform Bill allotted two seats to the four Scottish Universities, Playfair was returned as first member by a majority of 250.

His political career, though marked by the tenure of office, is remarkable rather for his effective work as a committee member than for any startling reforms in administration or legislation. Yet it must be remembered that the hinterland of all legislation in the nineteenth century was the select committee's report, and in this connexion his work is of the greatest significance. For as chairman of the commission of inquiry into the selection and staffing of the Civil Service, he was responsible for the report that bears his name. This report made possible the smooth running of the administrative machine that was being created by the increasing demands of the State. He was Postmaster-General at the end of Gladstone's first ministry, Deputy Speaker in the first three years of the second, and Vice-President of the Committee of Council (virtual Minister of Education) in the third. When Gladstone came to power for the last time, in 1892, Playfair was ennobled as Baron Playfair. Throughout he was a prominent speaker on all university questions, and did not hesitate to attack Gladstone for his attempt in 1873 to establish the Irish universities on the model of the University of London.

But throughout the years of opposition, Playfair returned to the subject which lay nearest his heart —the continuance of the work initiated by the Great Exhibition. The commission which had been set up to manage the South Kensington estates had landed itself in financial straits by overbuilding. When Playfair took over the honorary secretaryship in 1883, it was £180,000 in debt, with an annual deficit of £2,000. He remained in office for six years (until his seventieth birthday), and reduced the debt by £174,000, and had converted the annual deficit to a surplus. In addition, he had elaborated a scheme whereby the surplus funds could be utilized in research scholarships at home and abroad.

As Lord Playfair, he had every inducement to play the part of Nestor and leave the work to younger men; but emancipation from political office seemed to intensify his efforts to promote technical education. His last plea, a letter in *The Times* of February 8, 1897, advocated the completion of the art and science museums at South Kensington, then set in a squalor that did not suit the splendid collections which they already housed. His letter initiated a response from many who were anxious to commemorate Queen Victoria's diamond jubilee. It was a fitting last act of his life. A year after his death, the Queen laid the foundation stone of the Victoria and Albert Museum, and, as has been well said, so long as South Kensington exists, Lyon Playfair will not lack a memorial.

OBITUARIES

Prof. F. O. Bower, F.R.S.

Frederick Orpen Bower was born at Ripon in Yorkshire on November 4, 1855. He came of a long-established Yorkshire family. His father, Abraham Bower, J.P., was a man of leisure and his mother, Cornelia, was daughter of Rear-Admiral Henry Gage Morris. They had a family of three girls and two boys.

He frequently referred in later life to early happy days spent botanizing and bird nesting in the fields around Ripon, and there, no doubt, his interest in natural history was initiated. In 1868 he went to Repton School, and we find that his first published work, a poem in the heroic style on "Livingstone", won a prize. He was impatient at the lack of opportunity to study science, and on that account does not seem to have fully enjoyed his time at school. In 1874 he went to Trinity College, Cambridge. In Cambridge he found the official teaching in botany, to use his own words, "moribund in summer and actually dead in winter". When the English translation of Sachs' text-book of botany appeared in 1875 and he met S. H. Vines, the horizon brightened. He graduated with first-class honours in botany. He witnessed the conferment of an honorary degree on Charles Darwin. For a short time he lectured for a committee concerned with higher education of women, and he coached and worked in the laboratory with Vines. In 1877 he went with Vines to Würzburg, where he studied under Sachs, who evidently made a great impression on him.

In 1879, working under de Bary at Strassburg, he met a number of the most active continental botanists. Bower, Vines, Scott and other British botanists came back from Germany inspired by the instruction they received there in new aspects of botany and new technical advances in research. They introduced new vitality to the British schools, which had been concentrating on pure systematics and had been out of touch with the progress that was being made in other branches of botany on the Continent. Bower maintained in later years a close contact with his continental friends and was corresponding member of the Royal Academy of Turin and of the Botanical Society of America and a member of the Royal Society of Belgium, the Academy of Science of Munich and of the Royal Danish Society. His first published research was produced in Strassburg, on growth of the cell wall in *Dracæna* and on the development of the conceptacle of *Fucus*.

In 1880 he was assistant to Daniel Oliver at University College, London, and later became a lecturer under T. H. Huxley. While he held these posts he spent much of his spare time working at the Jodrell Laboratory at the Royal Botanic Gardens, Kew. Here was developed his interest in the vascular cryptogams, which were to occupy so much of his attention in later years. In 1885 he was appointed to the regius chair in Glasgow, which he occupied until 1925. When he went to Glasgow he found that his official teaching was restricted to the medical botany class in the summer term, and it was not until about 1893 that botany became a subject for the degree of B.Sc., and was taught throughout the session. He had, therefore, ample time for research, and between 1885 and 1886 spent about six months in Ceylon. He also continued to work during the winter months at Kew. He was an inspiring lecturer,

and many of his students and staff became imbued with his enthusiasm for the vascular cryptogams. Among those associated with him in the Glasgow department and who later took up posts in other universities were W. H. Lang, J. C. Willis, D. T. Gwynne-Vaughan, A. Anstruther Lawson, J. M. F. Drummond, R. C. Davie, J. McLean Thompson, J. McLuckie, D. Patton, Sheina N. Marshall and C. W. Wardlaw. He collaborated, too, with Robert Kidston, the palæobotanist.

Here in Glasgow was carried out that long series of anatomical investigations which culminated in the three-volumes publication "The Ferns" (1923–28). On the basis of sporangial structure and arrangement he formulated a system of classification which up to the time of his death had not been improved. His wider interest in the Archegoniatæ led to his production of "The Origin of a Land Flora" (1908) and "Primitive Land Plants" (1935). In these works he shows his skill in marshalling a large mass of evidence, the underlying theme being the development of the sporophyte generation in response to the environmental conditions of existence on land. His book on "Size and Form in Plants" appeared in 1930.

He collaborated with Vines and later with Gwynne-Vaughan in the production of books on practical botany. His elementary text-book, "Botany of the Living Plant", has gone into several editions. His last published book, "Sixty Years of Botany" (1938), gives a vivid and interesting picture of his scientific development and the personalities of those with whom he was associated.

In Glasgow he took up with his accustomed vigour and enthusiasm departmental and university affairs. He was an eloquent and inspiring lecturer. Many of his students will remember the difficulty of keeping up with him when on field excursions. He was an active member of the Senate, but it is said that at meetings when the business did not interest him he would bring out and work at botanical drawings until matters arose which required his attention. He served on the University Court and later (1929–39) held the honorary office of Dean of Faculties. His chief interest outside his botanical work was music. An accomplished 'cello player, he collaborated with a group of his friends at Cambridge in giving public concerts and later took an active part in chamber music in Glasgow. He was an original member of the Scottish Mountaineering Club.

With great foresight he compounded for life-membership when he was elected fellow of the Royal Society of London in 1891; in 1901 he was awarded the Royal Medal and in 1938 the Darwin Medal. He was awarded the Linnæan Medal of the Linnæan Society in 1901. He delivered the Huxley Memorial Lecture at the Imperial College in 1929.

In 1930 he was president of the British Association; he had been three times president of its Botanical Section, at Bristol in 1898, Australia in 1914, and Oxford in 1926. He was president of the Royal Society of Edinburgh during 1919–24, and was awarded the Neill Prize in 1926. Among many distinctions and honours he received honorary degrees from the Universities of Cambridge, Glasgow, Dublin, Aberdeen, Sydney and Bristol.

Bower had a brisk and confident manner with clean-cut likes and dislikes. These external characteristics tended to alarm some of those whom he met and prevented them from getting to know him more intimately; but those who got beyond this rather formidable façade found a man who was very charming, a great talker and very good company and always ready to help those in trouble. He had travelled in many lands and met many interesting people, and having a retentive memory was always worth listening to.

He spent a long and strenuous life in the pursuit of his science and lived to receive many honours. At the age of ninety-three his mind was still active and alert and he maintained a keen interest in the progress of botany.

On April 11 he died after a short illness, at Ripon, where he had lived in retirement since 1925.

J. Walton

The passing of Prof. F. O. Bower marks the loss to science of a great morphologist whose contribution to the study of the Pteridophyta not only extended greatly our knowledge of that group in respect to details of development and structure, but whose "Origin of a Land Flora" presented a synthesis of data and a philosophical approach that alike stimulated research and placed our concept of the vascular cryptogams on a different plane. The fact that to-day a discussion on homologous or antithetic alternation of generations would engender little enthusiasm is but one of the many examples in the history of science to show that sincerity of pursuit far transcends the theoretical basis of purpose to which the wealth of co-ordinated data accumulated by this great Victorian bears witness.

But no less is the debt to Prof. Bower which botanical science owes in that he initiated at University College, London, the first practical classes as we now understand them and thus imparted to the teaching of that day a reality that had been sadly wanting. As a former Quain professor in the department where Bower demonstrated, and director of the Institution where in the Jodrell Laboratory he carried out so many of his anatomical and morphological studies, I am glad to pay tribute to his memory.

E. J. Salisbury

Up to twenty years ago, the younger botanists of Britain and elsewhere found themselves grateful for the influence of Prof. Bower, then a pillar of British botany, whether they were of his Department or not. Though his own main researches were morphological, he showed a keen interest in other aspects of botanical science, especially when they were being expounded to him by a member of a younger generation—for then, as now, the science of botany was expanding and developing along new channels away from the old systematics and formal morphology. At times Bower deplored the tendency of the younger botanists to follow the paths of physiology, mycology and genetics; but mainly, I believe, because he suspected that his own field of morphology, and especially cryptogamic morphology, might consequently suffer. But such was Bower's loyalty to the progress of botany as a whole that he soon became imbued with enthusiasm when discussing the problems of younger botanists whose interests lay with the newer branches of the subject.

To capture Prof. Bower's interests in anything, whether it were plant physiology or chamber music, was to enter into an inspiring conversation which always left its mark. Yet the great Bower never wasted his time with any botanist whose work he suspected as not being first-rate. His influence on

British botany was widespread—far outside the research laboratory itself. His books must have inspired thousands of students, many of whom in due course entered the schools and thus transmitted to their even younger pupils the outlook on botany which they themselves had absorbed.

Though Prof. Bower left his Glasgow chair more than twenty years ago, his influence on British botany is still strong and will continue to be so for many years to come. L. J. F. BRIMBLE

Mr. J. L. Chaworth-Musters

JAMES LAWRENCE CHAWORTH-MUSTERS died on April 12. Born in 1901 at Annesley, Nottinghamshire, the son of a landowning family, the associations of his early youth with country life and pursuits led to an enduring interest in natural history, more especially in animals as living creatures. He was educated at Rugby and Caius College, Cambridge; but lack of sympathy with studies in which animals are more often seen as dead objects for dissection in the laboratory than as living organisms, and the horizons opened to him through participation in an expedition to Jan Mayen in 1920, impelled him to cut short his academic career. The possession of property in Norway resulted in his spending much time there, and he became deeply interested in the faunal differences he observed as compared with Britain. This interest was widened as he studied the subject; but he mainly concerned himself with mammals and birds, and commenced a serious study of the Palæarctic members of the groups at the British Museum (Natural History), with frequent field expeditions to collect and observe. His journeyings took him to Cyrenaica in 1926, the mountains of Greece in 1931, the U.S.S.R. in 1936, the High Atlas of Morocco in 1937 and Afghanistan in 1939; from all these expeditions he brought back new knowledge and additional material for study and to amplify the national collection.

When war came, Chaworth-Musters' knowledge of Norway and the Scandinavian languages resulted in his appointment as British vice-consul in Bergen. He was trapped there by the German invasion, but not captured; he left the consular offices by the back door as the enemy entered by the front. After months spent in hiding and travelling through the mountains, he eventually escaped to Britain in a fishing vessel. Photographs he brought back with him proved of great interest and importance to the Admiralty, and he was commissioned in the R.N.V.R. (Special Branch); the services he rendered were acknowledged by the award of the Norwegian Freedom Medal. When released from the Navy he at once returned to the British Museum to lend a hand in the formidable task of reconstruction, and was appointed a temporary assistant keeper.

His death has removed a colourful personality from the zoological world. He was as independent in mind as he was arresting in physical appearance. Always apparently impatient of detail and paper work, his published scientific papers are few; but his knowledge of palæarctic mammals was great. Though essentially a man of the country and little concerned with literature and the arts, he nevertheless read deeply, especially of the lives of the old naturalists and explorers. Simple in faith, he never lost the zest of youth. H. W. PARKER

NEWS and VIEWS

Physics at the University of Bristol: Prof. A. M. Tyndall, F.R.S.

AT the end of the present academic year, Prof. A. M. Tyndall will retire from the Henry Overton Wills chair of physics and complete his fiftieth year as a member of the University of Bristol. During those years he has been successively undergraduate, postgraduate student, lecturer, professor and acting vice-chancellor of the University, a continuous record probably unique in the English provincial universities. He entered University College, Bristol, in 1898, intending to qualify as an analytical chemist, but soon came under the influence of Prof. Chattock, who was responsible for the transference of his interest to physics. He succeeded to the chair of physics in 1919, and since then has promoted the growth of his department from modest beginnings to its present outstanding position in the world of science. His enterprise and initiative quickly attracted the generous support of the Wills family, and led to the building and endowment of the present H. H. Wills Physical Laboratory, which was opened in 1927. It required considerable courage to build so large a laboratory in what was then a small university; it could scarcely have been anticipated how well such a bold policy would be justified twenty years later.

Prof. Tyndall's most important original contributions to physics have been made on the subject of the electrical conductivity of gases, and he was early in this field with Chattock, making experiments on the 'electric wind'. By 1925 a whole literature on the subject had accumulated, running into some hundreds of papers; but the number of significant results was very small. Tyndall took the view that the lack of agreement in the measurements of different experimenters was due to impurities. The earlier workers had commonly employed apparatus constructed of brass, sulphur and similar materials, and made gas-tight, where necessary, with wax or rubber gaskets; substances all of which could give rise to impurities in uncontrolled amounts. He therefore first constructed apparatus using the new high-vacuum techniques which had recently been developed, and paid great attention to obtaining very pure gases. Secondly, he developed an ingenious new method of measurement, analogous to that employed by Fizeau to measure the velocity of light, the 'four-gauze' method. With this new technique, and working with a number of young colleagues, he measured the mobilities of a great variety of monatomic and monomolecular ions in most of the commonly occurring gases, in a wide range of temperatures. For this work he was elected a fellow of the Royal Society in 1931, and the main features of it are described in his well-known monograph on the subject.

It is a remarkable feature of Prof. Tyndall's career that, in addition to his original work, he has been able to give such a large proportion of his time towards establishing the conditions in which young workers could develop to the best advantage. It has never been his policy to devote himself primarily to his own researches; he has had at heart the success of every man working in his laboratory. Under his

direction, the work of the Wills Laboratory has shown a certain apparent diversity with an underlying unity; instead of a team working in one subject, he has collected around him a group of individuals, each following his bent and working on his own problems, and yet, through the constant discussions and the friendly spirit that he has created, helping and stimulating each other all the time. Nothing is more important, and nothing expresses more clearly the character and worth of the direction of a laboratory, than the general tone of the relations of the people in it, and no better tribute to Prof. Tyndall can be given than the fact that all those who have left his Laboratory have done so reluctantly. His relations with the undergraduate population of the University have displayed the same individual interest, and graduates who have qualified in his Laboratory remember him as a friend as well as a very gifted teacher. He will carry with him into his retirement a warmth of affection and an admiration that can rarely have been equalled, and with them a consciousness of the great part he has played in the development of the University of which he is so distinguished a graduate.

Prof. W. C. McC. Lewis, F.R.S.

THE retirement of Prof. W. C. McC. Lewis from the Grant-Brunner chair of inorganic and physical chemistry in the University of Liverpool marks the end of an epoch in the development of physical chemistry in Great Britain. His early work with Prof. F. G. Donnan on the experimental examination of the Gibbs adsorption equation is not only a classic in the field of colloid science, but also gave him, and afterwards his many junior workers, an interest in the physico-chemical and quantitative aspects of colloids. When the discovery of unimolecular reactions, especially in nitrogen pentoxide, raised the problem of the mechanism of molecular activation in an acute form, Lewis was one of the first with Trautz and Perrin to develop the radiation hypothesis of chemical activation. A series of most interesting and stimulating papers in this field shows the breadth and comprehensiveness of these investigations. While the radiation hypothesis is no longer tenable, the significance of the various 'quantum' relationships which obtain in many well-known physico-chemical relationships, for example, Trouton's rule, are still important and await a fuller treatment. Prof. Lewis's three-volume text-book on physical chemistry is one of the standard texts on the subject. The advantages for the readers of a comprehensive text-book written by one author are so evident that their thanks must surely be a recompense to anyone who undertakes such a monumental work.

Sugar Research Foundation Prize: Dr. Leslie F. Wiggins

DR. LESLIE F. WIGGINS, of the Department of Chemistry, University of Birmingham, has been awarded the third annual Sugar Research Foundation Prize of 5,000 dollars, administered by the National Science Fund on behalf of the Sugar Research Foundation, Inc. Dr. Robert C. Hockett, scientific director of the Foundation, described the work of Dr. Wiggins as "a milestone in the advance toward better use of cheap and abundant plant products to serve the myriad needs of civilization. With the depletion of coal and petroleum reserves, greater dependence must be put on utilizing the continuing supply of material produced by growing plants". He stressed the international character of the plan for studies of sugar as a food and an industrial material. Some phases have been undertaken in Britain through the Colonial Products Research Council and the Imperial College of Tropical Agriculture in Trinidad. Early this year Dr. Wiggins accepted an appointment as director of research in sugar technology at the latter College, and will continue to work at Birmingham until his institute in Trinidad has been built. He will also interest himself closely with projects of the Sugar Research Foundation in the United States and Canada.

Dr. Wiggins has made notable progress in using sugar as a raw material for chemical industry. The principal pathway is through the intermediate, lævulinic acid. Dr. Wiggins has worked out an efficient conversion method and gone on to make such varied products as sulpha drugs, analgesics, and nylon ingredients from the acid. The Birmingham School has also shown that the sodium salt of lævulinic acid makes a good anti-freeze, which can probably be made more cheaply than glycol or glycerine. Several drugs useful for reducing blood pressure, solvents, emulsifying and wetting agents, and a wholly chemical method for producing lactic acid have been developed. Through these channels it is expected that sugar will enter a wide range of uses, from plexiglass-type plastics to solutions for treating hides. In winning the third intermediate prize of 5,000 dollars, Dr. Wiggins becomes eligible for the grand award of 25,000 dollars to be given by the National Science Fund in 1950. The first Sugar Research Foundation prize was shared by Drs. W. Z. Hassid, H. A. Barker and Michael Duodoroff, for the first synthesis of sugar which has made possible 'tracer' studies of the metabolism of sugar in the human body. Dr. Carl F. Cori received the second annual award in 1947 for his contributions to the knowledge of how the body uses starches and sugars.

Mathematics at Birkbeck College, London: Dr. P. Dienes

PROF. PAUL DIENES, who is retiring from the chair of mathematics at Birkbeck College, London, came to Great Britain from Hungary via Paris twenty-seven years ago, after the upheavals of the First World War, as a representative of the Paris school of mathematics. His first line of research was complex function theory where, among other results, he established the outstanding fact that in many cases the type of divergence of the Taylor series reveals the type of singular behaviour of the function represented by that Taylor series. His results on this problem are collected in his monograph "Sur les singularités des fonctions analytiques" in Borel's collection. At the late Prof. G. H. Hardy's invitation he also wrote a substantial treatise, "The Taylor Series", on complex function theory (Oxford University Press). His second line of research was the differential geometry of curved spaces in connexion with relativity theory. His publications on this subject appeared in English, French and Italian periodicals. Prof. Dienes also obtained new results on infinite matrices and recently about Stieltjes integration. Besides these contributions to the main body of mathematics, he maintained a lively interest in logical and structural problems in connexion with the antinomies. His attitude towards philosophical problems in mathematics could be described as constructive-realist of the Borel–Brouwer type, rather than Russell's logicist-nominalist type.

Prof. A. C. Offord

PROF. A. C. OFFORD, who has held the chair of pure mathematics at King's College in the University of Durham for three years, is succeeding Prof. Dienes at Birkbeck College. Prof. Offord graduated at University College, London, and then proceeded to St. John's College, Cambridge, of which College he was a fellow from 1937 until 1940. He held a lectureship at the University College of North Wales, Bangor, for one year and then proceeded to a similar post at King's College, Newcastle-upon-Tyne. Later he was elected to the vacant chair of pure mathematics at that College. Prof. Offord's work is in the region of mathematical analysis, on certain branches of which he has produced many papers. Among others in collaboration with Prof. J. E. Littlewood of Cambridge, he has investigated the distribution of the zero values of a random integral function. More recently, also with Prof. Littlewood, he has been occupied with work on other values of a random integral function. This investigation shows that such a function has an extraordinarily regular growth. A long paper on this subject is to appear shortly in the *Annals of Mathematics*.

Coal Tar Research Association

A NEW industrial research organisation, the Coal Tar Research Association, has been set up by the British Tar Confederation (which is fully representative of producers and distillers of tar) on the basis of a scheme originally proposed by the Association of Tar Distillers. Dr. E. V. Evans has been elected president of the Association, and Mr. Richard Robinson is chairman of the council. Dr. D. McNeil has been appointed director of research. Dr. McNeil, who takes up his duties in July, is a graduate of the University of Glasgow, taking his B.Sc. with first-class honours in organic chemistry in 1935 and Ph.D. in 1938. After further postgraduate research at the Universities of Glasgow and Manchester as a Ramsay research fellow, he joined Imperial Chemical Industries (Billingham Division) in 1940 and has been engaged since then on research on petroleum and coal tar chemicals. The Coal Tar Research Association will set up its own laboratories as soon as circumstances permit; meanwhile, use will be made of such academic and industrial facilities as can be secured in various parts of the country. The present offices of the Association are at Gas Industry House, 1 Grosvenor Place, London, S.W.1.

George John Romanes (1848–94)

ONE of Darwin's most devoted disciples, George John Romanes, whose memory is kept green in the annual Romanes Lecture at Oxford, was born a century ago, on May 20, 1848, at Kingston, Canada. Fate was kind to him from the start, for his father inherited a fortune, so that the son, on leaving Cambridge, was able to devote himself to scientific research. At the age of twenty-five, a letter in this journal (*Nature*, **8**, 101; 1873) on the "Permanent Variation of Colour in Fish" won him Darwin's friendship. From 1874 until 1876 Romanes studied under Burdon-Sanderson at University College, London. For his work on echinoderms he was elected a fellow of the Royal Society in 1879. His more important publications include "Candid Examination of Theism" (1878), "Animal Intelligence" (1881), "Mental Evolution in Animals" (1883), "Mental Evolution in Man" (1888), "Examination of Weismannism" (1892), and "Darwin and after Darwin" (1892). During 1888–91 he was Fullerian professor of physiology at the Royal Institution, London. Early in life he thought of becoming a clergyman, and it is interesting to find that one of his last works, "Candid Examination of Religion", indicates a return to orthodoxy. A genial and versatile man, he was as fond of sport as of writing verse. His last years were spent in Oxford, where he died on May 23, 1894, after much ill-health. Two years after his death, his widow brought out the "Life and Letters of G. J. Romanes".

Enquiry

INCREASING interest in the phenomena investigated by psychical researchers appears to be the reason for the publication of a new periodical, *Enquiry*, of which the first number was issued in April (London: Horace Cox, Ltd. 1*s*. 3*d*.) The editors are Mr. Alfred Ridgway and Mr. Nigel Cox, and they are supported by an advisory panel of psychologists and others, among whom are Dr. William Brown, formerly Wilde reader in mental philosophy in Oxford, Dr. C. E. M. Joad, Prof. C. G. Jung and Dr. D. J. West, the research officer of the Society for Psychical Research. Although the editors do not themselves contribute an editorial introduction, a foreword is supplied by Prof. C. D. Broad, of Cambridge, who, after maintaining that telepathy is now an experimentally established fact and that there is excellent evidence to suggest that "in the case of some individuals" a part at least of the personality survives death, goes on to say that there is a strong unconscious resistance on the part of most men of science and philosophers to acceptance of these facts, and that he hopes that *Enquiry* may do its part in emphasizing them again and again. In the first issue of the new journal there are a number of interesting papers. Mr. J. W. Dunne contributes an article on "A Glimpse of the Real World"; the president of the Society for Psychical Research, Mr. W. H. Salter, has a paper on apparitions; the Dean of St. Paul's, Dr. W. R. Matthews, has a note on Dr. C. D. Kean's recently published "The Meaning of Existence"; and Dr. D. J. West describes some new methods for investigating physical mediumship and the lack of success in persuading any mediums to co-operate in using them. Finally, there is a long essay review by Martha Kneale of Mr. G. N. M. Tyrrell's recent book, "The Personality of Man", in which she stresses the need for clarity and the significance of psychical research for the human situation in general and more especially for ethics.

Greenkeeping Research

THE *Journal of the Board of Greenkeeping Research* (**7**, No. 23 (1947), St. Ives, Bingley, Yorks), last published in 1941, has made a welcome reappearance. The new number contains papers on moss in lawns and sports turf, the control of leatherjackets, maintenance of sea-washed bowling greens, and on earthworms; but perhaps the chief contribution is on experiments with selective weed-killers for sports turf by J. R. Escritt. 'Methoxone' can be used to control a number of common turf weeds if applied in fine sunny weather in spring or early summer. Suitable rates of application are 5 lb. of active principle per acre given as a spray, and slightly more (about 6 lb.) if used as dust. Daisy and clover are somewhat resistant, while yarrow, pearlwort, woodrush and moss are resistant to 'Methoxone'. 2:4-Dichlorophenoxyacetic acid (2:4 D) is also satisfactory as a weedkiller. It is best applied at 2 lb. per acre for

spray, and 4 lb. for dusting; but yarrow, pearlwort, woodrush and moss are again resistant. The value of 'Methoxone' has been endorsed by trials at numerous ports and golf clubs.

Mathematical Theory of Tetraploidy

THE mathematical theory of linkage between genes in a diploid organism is fairly well established. Prof. R. A. Fisher has now developed such a theory for tetraploids, and adumbrated one for hexaploids (*Phil. Trans. Roy. Soc.*, B, **233**, 55; 1947. 5*s.* 6*d.*). As it involves the theory of the partition of numbers, and that of matrices, most geneticists will find it difficult. However, the important conclusion is reached that complete information as to linkage in a tetraploid can only be reached if four different allelomorphs are available at each of two loci, and the limited accuracy of the estimates of linkage so far made is stressed.

Cinnoline Derivatives as Chemotherapeutic Agents for *Trypanosoma congolense* Infections

THE authors of the communication under this title published in *Nature* of April 17, p. 603, state that the concluding phrase should read: ". . . their contamination by hexœstrol, the dihydro derivative of (V)$^{3-6}$". The letter should also have included two further references to previous work, as follows: (5) Campbell, Dodds and Lawson, *Nature*, **142**, 1121 (1938); (6) Campbell, Dodds and Lawson, *Proc. Roy. Soc.*, B, **128**, 253 (1939).

Chemical Research Laboratory, Teddington

THE Chemical Research Laboratory (Department of Scientific and Industrial Research) at Teddington will be open to visitors during July 1–2. As in 1947, representatives of industry, government departments, universities and technical colleges will be invited to see the Laboratory and the work in progress, and it is hoped that industrial representatives particularly will take advantage of this opportunity. The five main branches of research are: (*a*) corrosion of metals; (*b*) high polymers and plastics; (*c*) coal tar constituents; (*d*) organic intermediates; (*e*) inorganic chemistry. Particular attention is paid at the Laboratory to new techniques of general usefulness. Industrial firms wishing to send representatives should write to the Director, Chemical Research Laboratory, Teddington.

British Museum (Natural History)

THE Coral Gallery of the British Museum (Natural History), which suffered damage during the War, has been reopened. This Gallery had been re-arranged only a short time before the War. The former systematic series of dried specimens of corals are replaced by interesting biological exhibits of reef corals, gorgonians, zoophytes and jellyfish, including a number of photographs and coloured drawings showing what these carnivorous animals look like when alive, how they grow and behave and feed. Their structure is explained, and compared with that of more highly organised animals. A series of jellyfish is shown, including a large 'football' medusa that is new to science.

Summer School in Electron Microscopy

A SUMMER SCHOOL in Electron Microscopy is to be held during August 18–24 in the Cavendish Laboratory, Cambridge. The School will provide a grounding in the theory and applications of the electron microscope. It is intended for those who have some familiarity with the instrument and who are already, or in the near future will be, operating it in physical, chemical or biological laboratories. The lectures will deal with the fundamental theory and operating principles of the electron microscope. The various techniques of specimen preparation will be demonstrated, and practised in small groups; the three leading models of instrument will be used. Forms of application for admission can be obtained from G. F. Hickson, Secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge; they must be returned not later than June 12.

Conference on Mechanical Wear

A SUMMER conference on mechanical wear, to be sponsored by the Massachusetts Institute of Technology, the American Society of Mechanical Engineers, the General Motors Corporation and the Chrysler Corporation will be held in Cambridge, Massachusetts, during June 14–16. The conference will be devoted to consideration of all aspects of wear between solid surfaces—its causes, symptoms and cures. In addition to the engineering aspects of this problem, papers will also be presented on the physical and chemical factors in wear. The speakers will include F. P. Bowden, R. Holm, H. Blok, R. H. Savage, R. G. Larsen and R. W. Dayton. Further particulars can be obtained from Prof. J. T. Burwell, Mechanical Engineering Department, Massachusetts Institute of Technology; Cambridge, Mass., U.S.A.

Institute of Petroleum: Officers

THE following have been appointed officers for 1948–49 of the Institute of Petroleum: *President*: E. A. Evans; *Vice-Presidents*: Dr. E. B. Evans, H. Hyams, Prof. V. C. Illing, J. A. Oriel, C. A. P. Southwell, H. C. Tett; *Hon. Treasurer*: G. H. Coxon; *Hon. Secretary*: C. Chilvers.

Physical Society: Officers

AT the annual general meeting of the Physical Society on May 5 the following were elected officers for 1948–49: *President*, G. I. Finch; *Vice-Presidents who have filled the office of President*, Prof. C. H. Lees, Sir Frank Smith, Sir Owen Richardson, Dr. W. H. Eccles, Prof. A. O. Rankine, T. Smith, Prof. Allan Ferguson, Sir Charles Darwin, Prof. E. N. da C. Andrade, Prof. D. Brunt; *Vice-Presidents*, A. J. Philpot, Dr. W. D. Wright, Dr. W. Jevons, Dr. W. S. Stiles; *Honorary Secretaries*, C. G. Wynne, H. H. Hopkins; *Honorary Foreign Secretary*, Prof. E. N. da C. Andrade; *Honorary Treasurer*, Dr. H. Shaw; *Honorary Librarian*, Dr. R. W. B. Pearse. All correspondence should be addressed to the Secretary/Editor, Miss A. C. Stickland, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

Announcements

UPON resigning his post as head of the Section of Natural Sciences in Unesco, Dr. Joseph Needham has been appointed honorary scientific adviser to the Organisation.

THE Society of German Chemists in the British Zone will hold this year's annual meeting in Hannover during September 1–4. Further details may be obtained from Prof. Werner Fischer, Institut für Anorganische Chemie, Technische Hochschule, Hannover.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Ultracentrifugation and Electron Microscope Studies of Tissues of Inbred Strains of Mice

It is now possible to report further progress since the appearance of our preliminary note[1].

By kind permission of Prof. E. K. Rideal, we have been able to examine tumour extracts, prepared as described in the previous communication, in the Bauer – Pickles ultracentrifuge of the Royal Institution. After centrifugation for two hours at a speed equivalent to 120,000 times gravity, the supernatant fluid was found to be entirely free from particles as observed in the electron microscope. The deposit consisted of particulate material of various sizes corresponding to those encountered in all our experiments with high-cancer-strain tissue extracts. Centrifugation for one to two hours at speeds equivalent to 50,000 and 60,000 times gravity gave supernatants still containing large numbers of the typical particles (Fig. 1). It would appear, therefore, from these trial experiments that the critical speed for complete centrifugation lies somewhere between 60,000 and 120,000 times gravity.

It has been established also that milk from *C3H* high-breast-cancer-strain mice, treated by the method employed in making our original normal and tumour tissue extracts, contains, when examined in the electron microscope, particles similar to those found in breast tumours and normal tissues of high-cancer strains. In milk, similarly obtained, of *C57* low-cancer-strain mice only occasional particles are to be found. In the few experiments so far undertaken with milk of high-cancer-strain mice, the number of particles has varied within wide limits, probably on account of difficulties in standardization of the conditions. In one preparation of milk taken direct from the stomachs of 5-day-old *C3H* mice a particularly rich crop of particles was obtained (Fig. 2); but it has not yet been possible to repeat this result at will.

The variation in the sizes of the particles is a matter under investigation. At the moment it would appear that the most frequent diameters are about 300 A., 200 A., and 350 A., in that order; but there are other particles of sizes up to about 1200 A. In some preparations obtained by centrifugation of *C3H* breast tumour extracts at 60,000 times gravity, which showed a preponderance of the smaller particles, a distinct tendency to regular crystallographic arrangement like that attained by certain plant viruses has been observed (Fig. 3).

Throughout these experiments all extracts examined in the electron microscope are tested concurrently for biological activity by inoculation into susceptible hybrids (*C57* × *R111*). In the earliest experiments reported on in our preliminary communication[1] some of the test hybrid mice have now developed mammary tumours, suggesting that the original high-cancer-strain preparations containing particles were biologically active.

For confirmation of this result it is still necessary to await the full findings in the case of test mice injected with low-cancer-strain preparations which contained no particles.

Fig. 1

Fig. 2

Fig. 3

Fig. 1. *C3H* (HIGH-CANCER-STRAIN) BREAST TUMOUR TISSUE: DRIED, TREATED WITH PETROLEUM ETHER, EXTRACTED WITH DISTILLED WATER, TREATED WITH TRYPSIN, FOLLOWED BY FILTRATION THROUGH BERKEFELD *N* CANDLE. APPEARANCE OF PARTICLES FROM THE SUPERNATANT FLUID AFTER CENTRIFUGATION FOR ONE HOUR AT ABOUT 60,000 *g*. CHROMIUM SHADOWED ON COLLODION FILM

Fig. 2. PARTICLES FROM MILK OBTAINED DIRECTLY FROM STOMACHS OF 5-DAY *C3H* STRAIN MICE. PREPARATION AND PHOTOGRAPHY AS FOR FIG. 1

Fig. 3. SAME TISSUE EXTRACT AS FOR FIG. 1; APPEARANCE OF PARTICLES IN THE SEDIMENT AFTER CENTRIFUGATION

SCALE ON EACH PHOTOGRAPH = 1 μ

R. D. Passey
L. Dmochowski

Dept. of Experimental Pathology and Cancer Research, University of Leeds.

W. T. Astbury
R. Reed

Dept. of Biomolecular Structure, University of Leeds.

P. Johnson

Royal Institution, London.

April 26.

[1] *Nature*, **160**, 565 (1947).

Molecular Arrangement in Tobacco Necrosis Virus Crystals

AN electron micrograph has already been published[1] showing elementary particles of the tobacco necrosis virus in the kind of symmetrical arrangement to be expected if they form part of a single crystal. Photographs have now been obtained which record the regular molecular distribution over several faces of polyhedra of this virus, and thereby demonstrate their truly crystalline structure. The preparations that show this have been atomic replicas made as in the earlier work, except that palladium has often been used as shadowing material instead of gold. This metal can also be stripped from glass and, as would be expected from its higher melting and boiling points, gives films less readily damaged under electron impact.

The way molecular alignment follows the crystal outlines in these photographs demonstrates that the original structure is preserved during dehydration. Nevertheless, necrosis virus crystals are probably like other protein crystals in containing water of crystallization the loss of which may produce distortions in the molecular array and a shrinkage in cell dimensions. At present, shrinkage cannot be estimated from the electron micrographs; but they do reveal disturbances in molecular arrangement. Accurate measurements on the photographs are now made difficult partly by these distortions and partly by a lack of precise knowledge of the angle between a replicated crystal face and the plane of the photograph. Though faults in structure may result from loss of water from the lattice, as implied above, they also may be natural imperfections in the original crystalline structure, or they may arise from either electronic damage to the replica in the microscope or from an inherent lack of faithfulness in the replica's reproduction of the crystal. Too often a choice cannot be made between these possibilities.

The angle of the molecular net reproduced in our earlier communication[1] and of the nets of many similar deposits departs by several degrees from 90°. This is not the case with the more massive crystals shown in the present photographs. Their principal face has a net that is square within the broad limits of experimental error. Molecular separations along the axes of these nets have been between *c.* 210 A. and *c.* 260 A., this variation being for the most part an expression of the distortions referred to in the preceding paragraph.

The photographs of Figs. 1–3 do not yet lead to a complete determination of molecular arrangement, but they leave few possibilities. The symmetry is at least pseudocubic, and all crystals have a habit that makes the same face dominant and approximately parallel to the plane of the photograph. This face with its square net has the indices (100). If the underlying lattice and structure are either simple cubic or body-centred, the axes of this net will be parallel to the cubic axes; if it is face-centred, close-packed, the axes of the unit cube are diagonal to the axes of the net. Crystals are bounded by pyramidal faces the intersection of which with the cube face is an axis of the net. The close-packed molecular net on these faces (Fig. 3) eliminates a simple cubic structure.

Several years ago X-ray reflexions[2] were obtained from a necrosis virus crystal before desiccation. These were interpreted in terms of a triclinic, pseudocubic, body-centred pseudo-cell containing two molecules and having the dimensions:

$$a_0 = 179\ \text{A.},\quad b_0 = 219\ \text{A.},\quad c_0 = 243\ \text{A.},$$
$$\alpha = 87\tfrac{1}{2}^\circ \quad \beta = 97\tfrac{1}{2}^\circ \quad \gamma = 97\tfrac{1}{2}^\circ.$$

Several strains of the necrosis virus have been described[3], and it is important to know if the same type of virus was used for X-ray examination and electron microscopy. This cannot be decided from the known histories of the preparations. The X-ray measurements would be compatible with the electron microscopic observations only if the short X-ray a_0-axis was approximately normal to the plane of the photographs. As seen in shadowed preparations, the individual particles of this virus appear to be spheres more than 200 A. in diameter. If the X-ray diffractions and the electron micrographs have dealt with the same virus, then the short axial length $a_0 = 179$ A. would require these particles to be very oblate spheroids within the crystal structure. Sufficiently accurate measurements on faces with close-packed nets could decide if the axis normal to the photographs can be so short as this. Only small faces have yet been found; but intermolecular distances of *c.* 240 A. obtained from the net shown at the top of Fig. 3 suggest that the crystals subjected to X-ray analysis were different from those that have been photographed in the electron microscope.

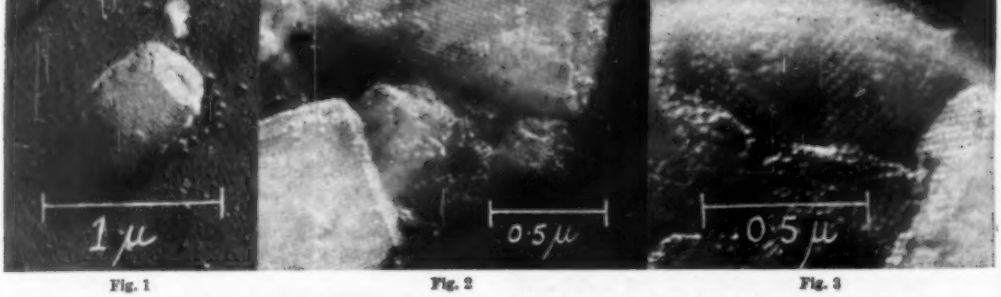


Fig. 1 Fig. 2 Fig. 3

Fig. 1. AN ELECTRON MICROGRAPH OF A SINGLE CRYSTAL OF A NECROSIS VIRUS PROTEIN. NOTE THE SQUARE NET ON THE TOP FACE AND THE CLOSE-PACKED NET ON THE PYRAMIDAL FACE TO THE LEFT

Fig. 2. AN ELECTRON MICROGRAPH SHOWING THE MOLECULAR ARRAY ON FACES OF SEVERAL NECROSIS VIRUS PROTEIN CRYSTALS

Fig. 3. AN ELECTRON MICROGRAPH SHOWING THE CLOSE-PACKED MOLECULAR NET ON A PYRAMIDAL FACE AND THE SQUARE NET ON THE ADJACENT FACE OF A NECROSIS VIRUS CRYSTAL

In a body-centred arrangement, spherical molecules of the square nets would not be in contact with one another. Such contact does seem to prevail in many photographs; hence, if the arrangement in the original crystal were body-centred, molecules must have suffered considerable distortion when incorporated into the lattice, or the lattice itself must have become distorted on drying in such a way as to bring molecules of the square net closer together, and thus to provide a structure approaching the close-packed arrangement. If the structure is not body-centred, it is close-packed. In this case, the pyramidal faces are octahedral with the indices (111). Such an interpretation fits well with the appearance of the crystal of Fig. 1, which thus would be bounded by the top cube face (100) and by four octahedral faces (111). It is equally compatible with the appearance of the crystals of Fig. 2 and with the information on other photographs if a reasonable measure of replica distortion is assumed. Best measurements on available electron micrographs indicate that the tetramolecular unit cube of such an arrangement would have an edge-length, measured along diagonals of the square net, of $a_0 = c.$ 340 A. Further studies are being made in the search for crystals which will establish, beyond doubt, whether or not this close-packed arrangement is correct.

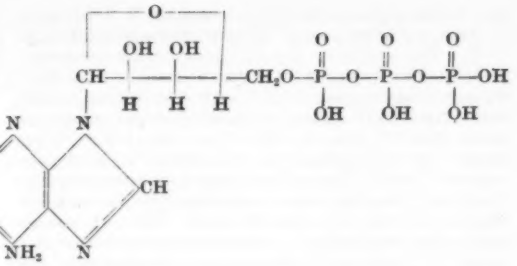
Roy Markham
Kenneth M. Smith
Plant Virus Research Unit,
Molteno Institute,
Cambridge, England.
Ralph W. G. Wyckoff
National Institute of Health,
Bethesda, Maryland, U.S.A.
Feb. 21.

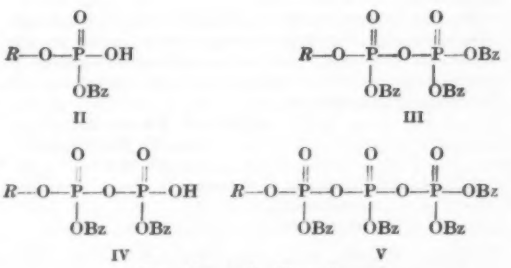
[1] Markham, R., Smith, K. M., and Wyckoff, R. W. G., *Nature*, **159**, 574 (1947).
[2] Crowfoot, D., and Schmidt, G. M. J., *Nature*, **155**, 504 (1945).
[3] Bawden, F. C., and Pirie, N. W., *Brit. J. Exp. Path.*, **23**, 314 (1942); **26**, 277 (1945).

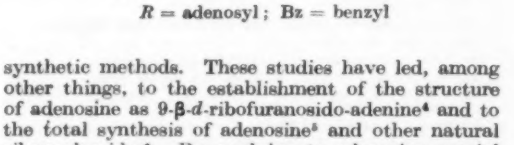
Synthesis of Adenosine Triphosphate

Since its isolation from muscle extracts in 1929[1], adenosine triphosphate has been the object of much biochemical interest. It plays a fundamental part in many biological processes, and it has found application in recent years in clinical medicine. On the basis of titration and other evidence, Lohmann[2] allotted to adenosine triphosphate the structure (I), in which it is formulated as adenosine-5′-triphosphate. Chemical evidence providing strong support for this structure has since been provided by Lythgoe and Todd[3], who showed that adenosine triphosphate, like muscle adenylic acid (adenosine-5′-phosphate) and adenosine, consumes 1 mol. sodium metaperiodate on titration with this reagent, whereas yeast adenylic acid (adenosine-3′-phosphate) is unaffected under similar conditions.

Final confirmation of structure (I) by total synthesis was clearly desirable, and such a synthesis, if it were realized, might have the added merit of making adenosine triphosphate a more readily accessible compound, since its preparation in a state of even approximate purity from muscle is a tedious and difficult matter. During recent years an extended series of investigations has been in progress in this Laboratory aimed at clarification of the structure of nucleosides and nucleotides by the application of







R = adenosyl; Bz = benzyl

synthetic methods. These studies have led, among other things, to the establishment of the structure of adenosine as 9-β-*d*-ribofuranosido-adenine[4] and to the total synthesis of adenosine[5] and other natural ribonucleosides[6]. By applying to adenosine special phosphorylation techniques developed in this Laboratory[7], muscle adenylic acid and adenosine diphosphate (adenosine-5′-pyrophosphate) have also been synthesized[8].

In the synthesis of adenosine diphosphate, the silver salt of adenosine-5′-benzylphosphate (II) was made to react with dibenzyl chlorophosphonate and yielded adenosine-5′-tribenzylpyrophosphate (III), which was not isolated but was directly hydrogenolysed to adenosine diphosphate. It was later found that the crude ester (III) contained appreciable quantities of a partially debenzylated material, adenosine-5′-dibenzylpyrophosphate (IV), and that, using a new method of partial debenzylation, all the tribenzylpyrophosphate present could be converted into the silver salt of the dibenzylpyrophosphate by warming the crude ester with *N*-methylmorpholine and afterwards precipitating with silver nitrate. When this silver salt was allowed to react with dibenzyl chlorophosphonate, it yielded a yellowish resin—presumably consisting largely of adenosine-5′-tetrabenzyl-triphosphate (V). The pure compound (V) was not isolated, but hydrogenolysis of the resin in aqueous dioxan solution gave adenosine-5′-triphosphate (I), which could be precipitated as a crude barium salt.

Enzymic assay[9] by the three enzyme systems adenosine triphosphatase, adenosine triphosphatase + myokinase, and yeast inorganic pyrophosphatase indicated that this product contained *c.* 40 per cent adenosine triphosphate, together with some adenosine diphosphate and free pyrophosphate. Purification of this material was effected *via* acridine and mercury salts; reconversion of the latter to barium salt gave the known di-barium adenosine-5′-triphosphate hexahydrate (found: N, 7·8; total P, 10·5 per cent; ratio of total P to acid-labile P, 3 : 2; inorganic P,

nil. $C_{10}H_{12}O_{13}N_5P_3Ba_2,6H_2O$ requires N, 7·9; total P, 10·5 per cent; ratio of total P to acid-labile P, 3 : 2). The synthetic product was further characterized by conversion to its tri-acridine salt, m.p. 209°, undepressed in admixture with the corresponding salt (m.p. 209°) prepared from natural adenosine triphosphate[10] (found: N, 10·4; total P, 8·9 per cent; ratio of total P to acid-labile P, 3 : 2; inorganic P, nil). The synthetic adenosine triphosphate liberated from the above acridine salt showed biological activity comparable with that of natural adenosine triphosphate regenerated from its acridine salt. Full details of this investigation will be published elsewhere.

We are grateful to Dr. K. Bailey for his invaluable assistance in carrying out enzymatic tests on the synthetic material, and for supplying a sample of purified barium salt of natural adenosine triphosphate for comparison purposes.

J. Baddiley
A. M. Michelson
A. R. Todd

University Chemical Laboratory,
Cambridge.
March 22.

[1] Lohmann, *Naturwiss.*, **17**, 624 (1929). Fiske and Subbarow, *Science*, **70**, 381 (1929).
[2] *Biochem. Z.*, **233**, 460 (1931); **254**, 381 (1932); **282**, 120 (1935).
[3] *Nature*, **155**, 695 (1945).
[4] Cf. Todd, *J. Chem. Soc.*, 647 (1946) for general review.
[5] Davoll, Lythgoe and Todd, *J. Chem. Soc.* (in the press).
[6] Howard, Lythgoe and Todd, *J. Chem. Soc.*, 1052 (1947). Davoll, Lythgoe and Todd, *ibid.* (in the press).
[7] Atherton, Openshaw and Todd, *J. Chem. Soc.*, 382 (1945).
[8] Baddiley and Todd, *J. Chem. Soc.*, 648 (1947).
[9] Bailey, *Proc. Biochem. Soc.* (in the press).
[10] Wagner-Jauregg, *Z. physiol. Chem.*, **239**, 188 (1936).

Photochemical Degradation of Starch

It became necessary, in the course of another investigation, to examine more closely the nature of the degradation suffered by polysaccharides when exposed to sunlight and in particular to ultra-violet light. The literature on the subject is meagre and often contradictory, and it was felt that this account of some of the observations we have made in what is practically a new field of research might be of interest to a wider circle.

This preliminary notice is primarily concerned with the degradation of amylose, the linear component of starch, although parallel experiments have been conducted with amylopectin and whole starch and, in addition, with maltose, glucose and α-methyl-glucoside. Amylose is rapidly degraded when it is exposed, in dilute solution and in the presence of air, to the influence of ultra-violet light of wave-length less than 3660 A. The destruction of the amylose is made manifest by a loss of iodine-staining power and is accompanied by the appearance in the solution of copper-reducing substances and of acids. The final product is carbon dioxide, and quantitative measurement shows that the whole of the carbon of the amylose ultimately appears as this gas.

When amylose (or amylopectin) was irradiated with filtered ultra-violet light of wave-length 3660 A., no decomposition of the polysaccharide was observed. If, however, zinc oxide was introduced into the solution, a rapid degradation of the amylose was initiated, as witnessed by the early appearance of reducing substances and the diminution and ultimate disappearance of iodine-staining power. A photosensitizer such as zinc oxide is not, however, a prerequisite of reaction if light of wave-length less than 3660 A. is present; for example, the unfiltered light of the mercury lamp. The course of degradation is essentially the same whether zinc oxide is present or not, although the initial rate of reaction is higher when the photosensitizer is present. It is not possible to measure acidity changes directly in the sensitized reaction, because the acids formed are neutralized by the zinc oxide; but changes in the zinc ion concentration (measured polarographically) run parallel with the variations in *p*H observed in the unsensitized reaction.

The course of degradation was followed by the measurement, at intervals, of (i) the copper reducing value (R_{Cu}) of the solution in terms of percentage conversion to glucose, (ii) the intensity of colour developed with iodine under standard conditions (absorption value), and (iii) *p*H of the solution in the unsensitized reaction or zinc ion concentration in the sensitized reaction.

The initial stages of degradation of amylose by irradiation in the presence of air resemble those brought about by acid hydrolysis, inasmuch as the absorption value of the solution diminishes and the reducing power of the solution increases, and when percentage of original absorption value is plotted against percentage conversion, the curve obtained has the same form as an acid hydrolysis curve. In a relatively short time, the solution completely loses the power of staining with iodine (the achroic point) and the reducing power developed then corresponds to 14 per cent conversion to glucose. Beyond this point, R_{Cu} increases more slowly until a maximum (21–22 per cent conversion) is attained. Thereafter, R_{Cu} diminishes, and the solution ultimately becomes non-reducing. The formation and destruction of the acid products keep in step with the changes in R_{Cu}. The *p*H falls to a minimum of 3·4 and then increases until the solution becomes neutral again.

Three products of the aerobic reaction have been identified and characterized beyond doubt, namely, formaldehyde, formic acid and carbon dioxide. The first has been isolated as the dimedone derivative, the second as its *p*-bromanilide and the third as barium carbonate. Formic acid appears to be the only acid (apart from carbon dioxide) formed in any quantity, and it is this acid which is mainly responsible for the *p*H changes. Contrary to the usual view, glucuronic acid is not produced, although traces are formed of a substance which gives a positive naphthoresorcin test. We have proved, however, that this test is very far from being specific for uronic acid. The formation of formaldehyde was followed polarographically and by the application of Schiff's test. It was also shown that acetaldehyde was not a product of the photochemical reaction. Neither formaldehyde nor formic acid can be responsible for the reducing power developed, since neither shows an appreciable R_{Cu}, as determined by the Shaffer–Hartman method.

On the basis of these and other observations which will be published in full elsewhere, we tentatively picture the main course of the photo-degradation of amylose in the presence of air as taking the form of three concurrent reactions:

Reaction A. The oxidation of amylose to an 'oxidized amylose' of the same average chain-length but having no iodine-staining power. The oxidized amylose reduces the Shaffer–Hartman reagent.

Reaction B. The light-catalysed hydrolysis of the oxidized amylose. This involves scission of the glycosidic linkages.

Reaction C. The oxidation of formic acid (and formaldehyde) to carbon dioxide.

It seems highly probable that reaction *A* is an oxidative attack on the α-glycol groups in the glucose members of the amylose chains, and is therefore of the same character as the oxidation effected by periodic acid or lead tetra-acetate. The oxidation of carbohydrates by periodic acid has been extensively studied by Hudson[1], and its mechanism elucidated. Formic acid is liberated from the non-reducing terminal monosaccharide member of a polysaccharide chain but not from the intermediate members, a fact which is put to effective use by Hirst and co-workers in the determination of the chain-length of amylopectin[2]. Formic acid is liberated also from the reducing end-group and is in this case accompanied by formaldehyde.

Reaction *B* sets free, from oxidized amylose, substances (for example, erythrose) which contain the α-glycol grouping and are therefore susceptible to further oxidation by reaction *A*. By the combined operation of the two reactions, amylose is converted into formic acid and formaldehyde, and it is from these that, by the photo-oxidation reaction *C*, the carbon dioxide is derived.

It must be stressed that the oxidizing agent in reactions *A* and *C* is molecular oxygen. Amylose is degraded when it is irradiated anaerobically (that is, in an atmosphere of highly purified nitrogen) but at an extremely slow rate relative to the aerobic reaction. The non-staining products formed are copper-reducing, but appear not to undergo further change. Furthermore, formic acid is not formed (only a very slight increase in acidity is observed) and no carbon dioxide makes its appearance. Our investigation of the anaerobic reaction is not yet complete; but it seems that the reducing end-products formed in nitrogen are resistant to further irradiation even in the presence of oxygen.

We are extending these investigations to include cellulose, and if it is found, as seems likely, that the course of reaction is the same, its implication in regard to the tendering of cotton textiles by light and air is obvious.

We wish to express our gratitude to Sir Norman Haworth for his advice and for the interest he has taken in this aspect of carbohydrate research.

S. Peat
E. J. Bourne
W. J. Whelan

Chemistry Department,
University,
Edgbaston,
Birmingham.

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Quantitative Chromatographic Estimation of α-Amino-Acids

Efforts have been made in the past to estimate α-amino-acids in mixtures by colorimetry of the product of the ninhydrin reaction[1]. Although the results with ninhydrin appear to be constantly reproducible for each acid, and each is quantitative with reference to its own standard, not all the amino-acids react exactly according to the theoretical equation. Consequently for this and other reasons colorimetric estimation of mixtures of amino-acids has been condemned[2].

The method of Consden, Gordon and Martin[3] by which individual amino-acids are 'spotted' on paper has again made it possible to attempt quantitative colorimetry. Various workers have used a 'semi-quantitative' method which depends on the size of the spot and the intensity of the colour; but they have not investigated systematically the effects of variation in *p*H, water content, ninhydrin concentration and the optimum time and temperature for the full development of the colour reaction. However, it has been found possible to estimate α-nitrogen in amino-acid mixtures by a chromatographic method based on an investigation of these variables. The procedure is as follows.

Locate the positions of the acids by treating the paper (Whatman No. 1) with 0·025–0·05 per cent ninhydrin in dry *n*-butanol. Heat in an air oven at 80° for three minutes, cool to room temperature and dry. Cut out the spots, leaving a margin, place each separate piece of paper in a dry test-tube and treat with 5·0 per cent ninhydrin in water-saturated *n*-butanol (about 6·5 per cent water), the water having been adjusted to *p*H 7·0 with Sørensen buffer of 0·1 per cent concentration The amount of the 5·0 per cent ninhydrin solution should be just as much as the paper will hold. Allow the tubes to stand at room temperature for 5 min.; place in a water bath at 55° for 5 min., then raise the temperature to 80° and maintain thus for 1–2 min. Cool the tubes to room temperature (3 min.) and extract the coloured product with 75 per cent acetone in water. Extraction is found to be complete in less than 20 min., and after shaking the suspension remains stable for 12 hr. or more.

With Ilford spectrum yellow filter 606 in the Hilger Spekker absorptiometer convenient quantities for the method are: 3 μgm. α-nitrogen in 0·02 ml. originally applied to the paper and extracted with 10 ml. acetone-water reagent will give an extinction, using a 1 cm. cell, corresponding to 0·300 on the drum. Hence using microcells it is possible to estimate in the accurate range of the instrument one-fifteenth part of the above; that is, 0·2 μgm. α-amino-nitrogen extracted with 2 ml. acetone-water reagent will give an extinction corresponding to 0·100 on the drum. The blank is small, being about 0·015. This procedure makes it possible to estimate the free α-amino-nitrogen of plasma, and by suitable concentration methods to estimate the partition of α-amino-acids in blood and tissue fluids.

The above figures refer to glycine, alanine and their straight-chain homologues. The basic amino-acids give very constant readings; but those acids which do not remain in solution at *p*H 7·0, such as tyrosine and cystine, give figures lower, but constant for themselves, since the coloured product is formed only above *p*H 2·5 and is stable only above about *p*H 4·5.

Further details of this work will be reported elsewhere.

L. Naftalin

Clinical Laboratories,
Victoria Infirmary,
Glasgow.
Feb. 14.

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Quantitative Paper Chromatography

We have recently developed a simple method for quantitative assay of amino-acids on the paper partition chromatogram. The method is in all probability applicable to any class of substance which can be readily located by means of a sensitive colour-reaction on paper. Several technical points of general interest have arisen in the course of the work.

(1) *Effect of concentration on the resolution of spots.* When a series of dilutions of a mixture of amino-acids is run on a paper chromatogram (one-dimensional) the size of spot diminishes regularly with increasing dilution. Fig. 1 illustrates a run in phenol (plus 0·7 per cent ammonia) using 5 μl. spots of dilutions of a mixture of glutamic acid, glycine and alanine (all 0·062 *M*). The dilution factor is 2/3, and the spots were developed in the usual way with ninhydrin. The figure demonstrates that serial dilutions could be of great value in the resolution of a complex mixture, and also that the R_f of an amino-acid varies with concentration, the nature of the variation differing for different amino-acids.

(2) *Methods for quantitative assay of amino-acids.* Starting from the observation that the size of spot shows a regular relation to dilution, we have investigated three different measures of spot size in relation to amount of amino-acid present.

(*a*) The simplest procedure, applicable only to conditions in which regular ovoid spots are obtained, is to measure the maximum extension of the spot in the direction of solvent flow. There is a linear relation between length of spot and logarithm of content of amino-acid.

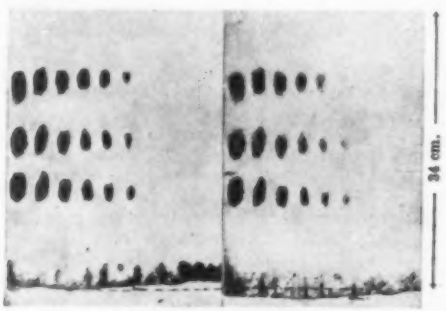

Fig. 1 Fig. 2

(*b*) A more generally applicable procedure is to outline the spot on the chromatogram and to measure its area by planimeter. Measurements by three observers on independent tracings of glutamic acid spots from the same chromatogram are given in the accompanying table. These areas are linearly related to the logarithm of the amount of amino-acid present, as shown in Fig. 3. The data at present available suggest that it may be possible to detect a 2 per cent difference in the amount of amino-acid present, using the means of quadruplicate estimates.

Successive dilutions	Independent estimates of spot area—in arbitrary units (glutamic acid)		
	Observer I	Observer II	Observer III
Original	92	91	93
1st dilution	80	83	79
2nd ,,	68	69	67
3rd ,,	60	60	63
4th ,,	47	49	46
5th ,,	34	28	33

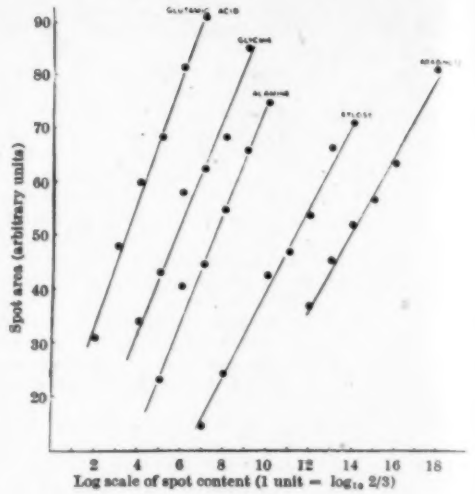

Fig. 3

(*c*) We have also used a Hilger photomicrometer to scan a quarter-plate negative prepared from the original chromatogram. After plotting the transmission curve, the area between the base line and this curve was used, for each spot, as a measure of the content of amino-acid. This area bears a linear relation to the amount of amino-acid present, but only over a restricted range of amounts of amino-acid.

The use of spot areas (method *b*) is far more convenient than method (*c*) and more generally applicable than method (*a*), and promises adequate accuracy for most purposes. We propose to use it in the form of an assay technique, in which standard amino-acid mixtures are run side by side with unknowns. Such a procedure obviates the necessity for the determination of the parameters of the line relating spot size to spot content, and compensates for the effect of variation in paper, solvent, temperature and other factors on these parameters.

The absolute amounts of amino-nitrogen required for a single spot are in the region of 0·3–3·0 μgm., so that the spot area method is of much the same order of sensitivity as the microbiological methods. The method is also, in all probability, applicable to classes of compound other than amino-acids. We have already shown it to be capable of use for sugars. The two right-hand lines of Fig. 3 relate to runs of serial dilutions of xylose and arabinose in phenol, the original solutions containing 40 μgm. of sugar per 5 μl. spot. The spots were developed with ammoniacal silver nitrate[1]. It is obvious that the same sort of relation between spot size and spot content is obtained as with the amino-acids.

(3) *A photographic aid to the spot area technique.* The accurate assessment of spot area requires that the spots should have a sharp edge. This condition does not always obtain for amino-acid spots developed with ninhydrin; but we have found that the spots on a copy of the chromatograph made with a commercial reflex copier (Miles Aircraft Co. 'Copycat') have the desired sharpness.

Fig. 1 is a 'Copycat' reproduction, and Fig. 2 is an intensified orthodox photograph of the same

chromatogram. The original of Fig. 1 provided the data tabulated in the table.

R. B. Fisher
D. S. Parsons

Department of Biochemistry,

G. A. Morrison

Department of Physical Chemistry,
Oxford.
Jan. 27.

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The Fourier Method of Crystal Structure Analysis

The method of Fourier synthesis from observed X-ray reflexion intensities has been widely used as a means of determining interatomic bond-lengths and bond-angles. Alternative methods of deriving accurate atomic co-ordinates from X-ray diffraction data have been suggested by Hughes[1] and by Booth[2]. Their methods are similar in that the co-ordinates are chosen so as to minimize some function of the observed and calculated structure amplitudes, F_o and F_c. Hughes, for example, chooses co-ordinates which minimize $\Sigma w(F_o - F_c)^2$. The weighting factors w are introduced to allow for the fact that the F_o's are not all measurable with the same accuracy. An obvious weakness of the Fourier method is that all F_o's, including those few likely to be systematically in error because of extinction, etc., are included as coefficients in the Fourier series and must therefore influence the result. The omission of certain coefficients from the series because they cannot be observed experimentally except with radiation of very short wave-length also leads to 'finite summation' errors[3].

Closer investigation of the theory of the Fourier synthesis of centro-symmetrical functions has shown that the Fourier and least-squares solutions are closely related, and that in crystal structure analysis the atomic co-ordinates derived by Fourier synthesis make $\sum_N \frac{1}{f}(F_o - F_c)^2$ a minimum. f is the atomic scattering factor, and $\sum_N$ denotes a summation over the N terms included in the Fourier series, which is assumed to be completely convergent. This result leads to others which should be of practical value.

(1) Any coefficient(s) of the Fourier series can be given reduced weight by carrying out a second synthesis in which F_o is replaced by $wF_o + (1-w)F_c$, as it can be shown that this procedure minimizes $\sum_N \frac{w}{f}(F_o - F_c)^2$. In particular, observations affected by extinction can be given zero weight by replacing F_o by F_c in this subsequent synthesis. This result is approximate only, but the approximation is a good one if the number of terms given reduced weight is a small proportion of the total.

(2) If the Fourier series is terminated and includes only n terms, the function minimized is $\sum_n \frac{1}{f}(F_o - F_c)^2 + \sum_{N-n} \frac{1}{f} F_c^2$. However, it may be shown that after correction of the co-ordinates for finite summation by the method first suggested by Booth[3], the function minimized is $\sum_n \frac{1}{f}(F_o - F_c)^2$, that is, zero weight is given to the $N - n$ terms which were not observed experimentally. This constitutes a theoretical justification of Booth's method.

(3) The effect of introducing a converging factor—usually called an artificial temperature factor and given the form $\alpha = \exp[-B \sin^2\theta/\lambda^2]$—is to minimize the function $\sum_N \frac{\alpha}{f}(F_o - F_c)^2$. Less weight is thus given to structure amplitudes of high order, as might have been anticipated. An interesting result is obtained by taking $\alpha = f$; the co-ordinates given by the Fourier method now render $\sum_N (F_o - F_c)^2$ a minimum, which is the least-squares solution with all observations given unit weight. A practical objection to the use of an artificial temperature factor is that unless the atoms are more widely separated than is generally the case, their electron distributions begin to overlap and the point of maximum electron density of one atom may be moved by the 'tail' of another.

Finally, it may be remarked that the close connexion between the Fourier and least-squares solutions shows that no great increase in accuracy can be obtained by abandoning the Fourier method.

A fuller account containing proofs of the results quoted above will be published elsewhere.

W. Cochran

Crystallographic Laboratory,
Cavendish Laboratory,
Cambridge.
Feb. 7.

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A New Fourier Refinement Technique

It has been shown by Cochran[1] that the ordinary process of Fourier refinement, used in X-ray structure analysis, is equivalent to minimizing the function:

$$\varphi = \sum_{h,k,l} \frac{1}{f}(|F_o| - |F_c|)^2, \qquad (1)$$

where f is $f(h,k,l)$, the mean atomic scattering factor for the (h,k,l) plane; F_o is $F_o(h,k,l)$, the observed structure factor; and F_c is $F_c(h,k,l)$, the calculated structure factor.

In this note it will be demonstrated that, with trifling modification, the standard Fourier technique can be used as a crude form of steepest descent[2], and that, in this form, it may be possible to obtain convergence in two important cases where Fourier synthesis normally breaks down. These occur when: (*a*) the initial co-ordinates are *very* far from the true ones; (*b*) the synthesis, either partly or wholly, fails to resolve. Let ρ_o be electron density calculated from *observed* $F_o(h,k,l)$ and *calculated* phase angles $\alpha_c(h,k,l)$, and ρ_c be electron density from *calculated* $F_c(h,k,l)$ and *calculated* phase angles $\alpha_c(h,k,l)$.

Then, if $\theta = 2\pi(hx/a + ky/b + lz/c)$

$$\rho_o = \sum_\theta |F_o| \cos(\theta - \alpha_c), \qquad (2)$$

$$\rho_c = \sum_\theta |F_c| \cos(\theta - \alpha_c); \qquad (3)$$

whence

$$(\rho_o - \rho_c) = \sum_\theta (|F_o| - |F_c|) \cos(\theta - \alpha_c). \qquad (4)$$

Suppose the $|F_c|$ and α_c to have been calculated from a set of co-ordinates (x_r, y_r, z_r) then, when the correct structure is obtained and maxima in the observed and calculated distributions coincide,

$$\left[\frac{\partial\,\rho_o - \rho_c}{\partial x}\right]_r = \sum_s (|F_o| - |F_c|)\{-(2\pi h/a)\,.\,\sin(\theta_r - \alpha_c)\} = 0, \quad (5)$$

with similar equations for the y and z derivatives. Now it has been shown that[3]:

$$\frac{\partial\,|F_c|}{\partial x_r} = -(2\pi h/a)\,.\,\sin(\theta_r - \alpha_c)\,.\,f_r, \quad (6)$$

whence (5) may be written:

$$\left[\frac{\partial(\rho_o - \rho_c)}{\partial x}\right]_r = \sum_s (|F_o| - |F_c|)/f_r\,.$$

$$\frac{\partial\,|F_c|}{\partial x_r} = -\frac{1}{2}\frac{\partial}{\partial .\,r}\sum_s (|F_o| - |F_c|)^2/f_r = 0, \quad (7)$$

with similar equations for y and z. These equations imply the Cochran result, but also will be seen (with a trivial change of notation) to be the variable quantities $\partial\varphi/\partial x_{rj}$ in the equations for steepest descent corrections[2]:

$$\left.\begin{aligned} \varepsilon_{rj} &= \frac{-\varphi_o}{\sum_{si}(\partial\varphi_i/\partial x_{si})^2}\,.\,(\partial\varphi/\partial x_{rj}) \\ \text{or} \\ \varepsilon_{rj} &= \frac{-\sum_{si}(\partial\varphi_i/\partial x_{si})^2}{\sum_{si,s'i'}\partial^2\varphi_i/\partial x_{si}\partial x_{s'i'}\,.\,\partial\varphi_i/\partial x_{si}\,.\,\partial\varphi_i/\partial x_{s'i'}}\,.\,(\partial\varphi_i/\partial x_{rj}) \end{aligned}\right\} \quad . \quad . \quad . \quad (8)$$

where φ is defined as in equation (1). One point should be made clear: these comparisons are rigorous only under the assumption that all the atoms have the same scattering factor, and to the extent to which this is untrue deviations will occur; these should, however, be small for structures containing only the usual carbon, oxygen and nitrogen atoms.

It follows (with the above reservations) that the ordinary Fourier refinement process—(*a*) calculate phase angles from assumed co-ordinates; (*b*) compute atomic co-ordinates from the maxima of ρ_o as defined in equation (2); (*c*) repeat from (*a*) with the co-ordinates resulting from (*b*)—tends to move all of the atoms in the *directions* required by the steepest descents process but not necessarily by the correct amounts. In addition, when the Fourier map does not resolve, the placing of the new atomic positions is largely a matter of guesswork.

Equations (7) and (8) give the key to a method of improving this state of affairs for, if a map of the function $(\rho_o - \rho_c)$ be drawn and the positions of the (x_r, y_r, z_r) used to calculate α_c are marked upon it, the *directions* of greatest *ascent* at these points give the directions in which the steepest descent procedure requires the atoms to be moved in order to decrease φ most rapidly. Furthermore, the *gradients* at these points are proportional to the magnitudes of the *vector* corrections required for the separate atoms.

If there is no special reason for wishing to see the ρ_o map, the above process will not involve more work than the standard refinement technique, since the $(\rho_o - \rho_c)$ synthesis can be computed directly from the coefficients $(|F_o| - |F_c|)$. For well-resolved syntheses *only*, the ρ_o map is itself sufficient since the points (x_r, y_r, z_r), by definition, are stationary points in the ρ_c map, and the slopes of ρ_o at these points give the required information.

Up to now, nothing has been said regarding the absolute magnitudes of the necessary corrections but only of their directions and relative proportions. Probably the simplest procedure is to observe which atom is to be most displaced (it will have the greatest slope in the $(\rho_o - \rho_c)$ map), and to take as the magnitude (but *not* direction) of its correction a distance equal to that from its centre to that of the adjacent maximum in the $(\rho_o - \rho_c)$ distribution. If this displacement is represented by ε_{max}, the displacements of all other atoms are given by:

$$\varepsilon_r = \frac{\text{gradient at atom } (r)}{\text{gradient for atom max.}} \times \varepsilon_{max}. \quad (9)$$

The effects of differing scattering factors can be easily removed at this stage by modifying (9) to read:

$$\varepsilon_r = \frac{f_r}{f} \times \frac{\text{gradient at atom } (r)}{\text{gradient for atom max.}} \times \varepsilon_{max}; \quad (10)$$

and in this case the identity of the method with that of steepest descents becomes exact, not only with respect to the direction of movement of individual atoms but also with respect to the magnitude of these measurements.

In most cases it will be found that the co-ordinates derived from these displacements will decrease φ; if this is not the case, however, or if a more precise estimate of the minimum is required, φ may be calculated for co-ordinates obtained with twice this set of corrections and a simple quadratic interpolation made to determine those corrections required to minimize φ. At this stage the whole process of calculating the $(\rho_o - \rho_c)$ map is repeated and further refinement made with the new set of descent directions thus resulting.

A final observation may be made. The above discussion makes it clear that the normal Fourier refinement technique, in which the new atomic positions are taken to be those of the maxima of ρ_o, is incorrect, and that much better convergence would be obtained by taking as new co-ordinates those of the maxima in the $(\rho_o - \rho_c)$ space, although for the early stages of a determination this will still be much inferior to the true steepest descent method.

ANDREW D. BOOTH

Physics Department,
Birkbeck College,
London.
Jan. 31.

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Spectral Sensitivity of Lead Telluride Layers

MICROCRYSTALLINE layers of lead telluride can be made which show photo-conductivity when illuminated with infra-red radiation. Such layers are similar to the better-known lead sulphide and lead selenide layers, and it has been generally assumed that the sensitivity of lead telluride would extend to longer wave-lengths.

War-time measurements made in Germany[1] and a recent measurement by Simpson, Sutherland and Blackwell[2] differ considerably. This difference may be due to the 'window' materials used on the German cells, to the use of layers of different thickness, or to a fundamental difference in the material itself, depending on the method of preparation.

For the measurements described in this note, cells were constructed with windows of *KRS 5* material

having a uniform transmission of 65 per cent from 1 to 35 μ. The cells were made in the usual Dewar flask form; but had the outer wall continued about three inches beyond the end of the inner wall which carried the electrodes. The window was waxed to the end of the cell, which was mounted vertically inside an oven with the window protruding through a hole in the bottom. Throughout the subsequent heat treatment the window was kept cool by immersion in water.

Initially the lead telluride was evaporated on to the walls of a side tube sealed into the outer wall opposite the electrode surface, and then baked at 440° C. (that is, just below the sublimation point) for several hours, all under a good vacuum. The basic material was made with a slight excess of tellurium, and the object of the baking was to remove this excess so far as possible. After baking, the cell was allowed to cool and the lead telluride evaporated on to the electrodes by means of a flame, the electrode surface being cooled by water. It was found that the layers were only sensitive when cooled below about − 50° C.

Results of measurements carried out on two layers at various temperatures are given. Fig. 1 shows the spectral sensitivity (in arbitrary units) at temperatures of solid carbon dioxide, liquid oxygen and liquid hydrogen. It will be seen that the form of curve obtained differs considerably from that found by Simpson, Sutherland and Blackwell. The form is, however, very similar to those found in this laboratory for lead sulphide[4] and lead selenide[3]. The curves consist of an approximately flat region followed by a sharp fall in sensitivity as the wave-length is increased. The 'threshold' of sensitivity, defined as the point at which this falls to 50 per cent of its value over the flat portion of the curve, occurs at 4·1 μ at 195° K., 5·0 μ at 90° K. and 5·9 μ at 20° K. Contrary to expectation, the figure for 90° K. is almost identical to that found for lead selenide[3]. A linear relationship is found between the quantum energies associated with these 'threshold' values and the temperature, as will be seen from Fig. 2. This has also been found to hold for lead sulphide cells[4].

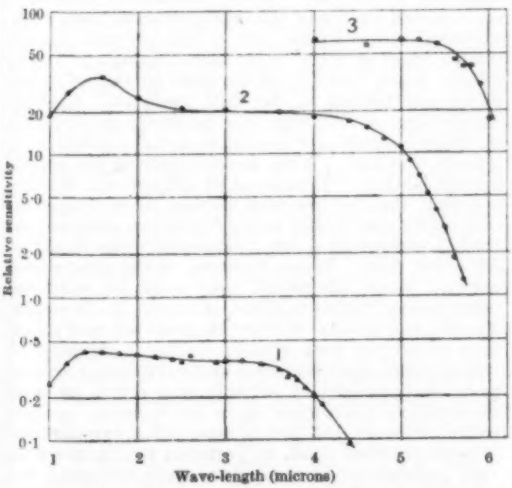


Fig. 1. SIGNAL OUTPUT FROM LEAD-TELLURIDE LAYER FOR CONSTANT INCIDENT ENERGY
Curves 1, 195° K.; 2, 90° K.; 3, 20° K. (all on same scale)

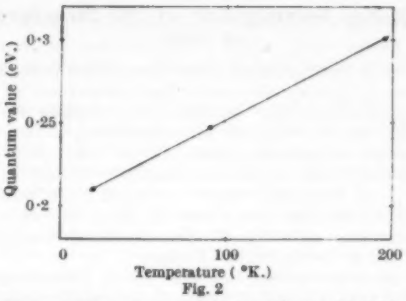


Fig. 2

Measurements on a second cell at 195° K. and 90° K. give 'thresholds' at 4·1 μ and 4·7 μ respectively. The reason for the difference in 'threshold' wave-lengths of these two cells at 90° K. may be due either to a dissimilarity in the transmission of the two layers, or to a difference in the minimum quantum energy required to cause appreciable photo-conductivity. It is known that the absorption of lead sulphide and lead selenide varies over this region of the spectrum, falling off at the longer wave-lengths, and it is expected that lead telluride would behave similarly. Thus if a layer is too thin, it may absorb all the incident quanta (neglecting the reflexion loss) at shorter wave-lengths, but only a fraction of them at longer wave-lengths. This would alter the shape of the sensitivity curves, and would reduce slightly the 'threshold' wave-lengths.

The layers were made of considerable thickness in an attempt to ensure that they would absorb practically all the incident energy over the whole spectral range, so that the measurements would yield a sensitivity curve proportional to the photo-efficiency of the material, that is, give the variation in the number of conduction electrons produced for constant absorbed energy.

The thickness of the first layer was found to be approximately 1·0 μ, and the second 0·7 μ. Thus the additional thickness of the first layer is possibly the cause of its longer wave-length 'threshold'. Experimentally it is very difficult to check if there is any transmission through the layers when cooled, and this has not so far been done.

Sensitive layers of lead telluride are simpler to produce than those of lead selenide. The best cell so far made in this laboratory (area 10 mm.²) gave signal = r.m.s. noise for a signal of 3×10^{-10} watts in a 1 c.p.s. band-width at 800 c.p.s. These results, which are of a preliminary nature, show that these cells are very efficient infra-red detectors for wave-lengths up to about 5·0 μ, or 6·0 μ if the experimental difficulties of working with liquid hydrogen are not prohibitive.

I wish to thank Prof. F. Simon, of the University of Oxford, for providing a supply of liquid hydrogen; D. E. Blackwell, O. Simpson and G. B. B. M. Sutherland for communicating their results prior to publication[2]; and the Chief Scientist, Ministry of Supply, for permission to publish this note.

T. S. Moss

Physics Department,
Telecommunications Research Establishment,
Great Malvern.
March 31.

[1] Elliott, "Electronics", Chapter 3 (London: Pilot Press, 1947).
[2] Simpson, Sutherland and Blackwell, *Nature*, **161**, 281 (1948).
[3] Moss and Chasmar, *Nature*, **161**, 244 (1948).
[4] Moss, *Nature*, **158**, 476 (1947).

X-Ray Investigation of the Structure of Jute

JUTE is distinguished from most other plant fibres by the occurrence in it of a high proportion of non-cellulosic materials. Normal jute contains roughly 64 per cent of cellulose, the remainder of the fibre-substance comprising lignin (15 per cent) and hemicelluloses, xylan (11 per cent) and polyuronides (9 per cent); in contrast, ramie is almost pure cellulose. We have studied the effect of these non-cellulosic constituents on some of the structural features of the fibre as revealed by X-rays.

It is well known that the X-ray photograph of normal jute is a rather diffuse cellulose diagram with a considerably enhanced background scattering; superposed on this there is a broad Debye – Scherrer ring of mean spacing 4·2 A., and this, as well as at least part of the background, we have shown to be due to lignin. The diffuseness we attribute to small crystallite size and crystalline imperfections, both perhaps consequences of the inhomogeneity of the structural material. Apart from these more obvious features of the X-ray photograph, we have also observed equatorial reflexions of spacings 9·7 A. and 14·6 A. which are not present in photographs of ramie taken under the same conditions, and are not accepted cellulose spacings. That they are in some way associated with the lignin is shown by the fact that they can be made to disappear by appropriate treatment of delignified jute, but not, as far as our experience goes, so long as lignin remains in the fibre*. There is some evidence, as yet not very conclusive, that the smaller spacing is also associated with xylan and the other with the polyuronides. Similar spacings to these have recently been observed in bamboo fibres[1].

Lignin (%)	% hydrate	(101) spacing (A.)
0·0	100	7·6$_0$
0·3	91	7·5$_8$
2·0	85	7·4$_9$
6·0	81	7·4$_3$
9·0	83	7·6$_0$
11·0	86	7·8$_3$
Normal jute	84	8·3$_0$

The presence of lignin modifies the response of the jute to the mercerizing action of caustic soda solutions. We find, for example, that the (101) spacing of the hydrate pattern of jute treated without tension in 20 per cent caustic soda solution at 20° C., measured at room humidity under desorption conditions, decreases at first as the lignin content is reduced, reaching a minimum when about two-thirds of the lignin has been removed (see table). This behaviour, however, is largely, if not entirely, an expression of the different swelling properties of the jutes of different lignin contents, for our results show that normal jute and jute samples containing 0 per cent and 6 per cent of lignin all give approximately the same spacing, 7·4 A., when dried over phosphorus pentoxide. The agreement of this with the value for dry cellulose (ramie, accepted value 7·3 A.) refutes the suggestion recently put forward by Sirkar and Saha[2], on grounds based on a comparison of the room humidity spacing in jute with the dry value for ramie, that there is something abnormal in the cellulose II in mercerized jute.

The figures for the proportion of the hydrate modification shown in the table indicate that the swelling of jute in caustic soda solutions also depends on the lignin content; there is a suggestion here, too, of a trend similar to that shown by the spacing measurements. These and other results will be discussed in detail elsewhere.

* *Note added in proof* (*May* 3). Further work on the occurrence of these reflexions has shown that they are affected (in intensity, at least) by humidity, appearing at their strongest in wet fibres and weakly, if at all, in fibres thoroughly dried. Similar reflexions of greatly reduced intensity have also been observed in the purer cellulose fibres under certain conditions. For these results we are indebted to Mr. R. R. Mukherjee.

M. K. SEN
H. J. WOODS

Textile Physics Laboratory,
Department of Textile Industries,
University, Leeds.
Jan. 22.

[1] Preston, R. D., and Singh, K. (private communication).
[2] Sirkar and Saha, *Nature*, **157**, 839 (1946).

Animal Tissue Culture with a Synthetic Medium

IN a recent communication in *Nature*, Jensen[1] reported some experiments on animal tissue cells *in vitro* employing, in parts, protein-free media. He observed with very small explants (embryonic heart tissue) a modest degree of survival and migration. This stands in contrast to the long-continued growth described by P. R. White[2] of animal tissue cells in an entirely synthetic medium. However, Jensen raises certain criticisms of White's technical procedure with which we concur. Our own experiments were carried out last year, in order to substantiate such criticism.

With the exception of carotene and vitamin A, which we omitted, our synthetic nutrient fluid corresponded to that described by White. In order to make the experimental conditions as stringent as possible and to rule out the presence of important unknown compounds (tissue breakdown products, etc.) carried over into the culture vessels from fresh explants, we used pure populations of fowls' macrophages (derived from 'buffy coat') living, in a unicellular layer, attached to the glass bottom of Carrel flasks and bathed in the fluid medium. Healthy populations of this type can be shown to live and multiply actively, for weeks, in serum diluted with Tyrode solution[3]. When in such cultures the serum-Tyrode mixture was replaced by 100 per cent White's nutrient, the cultures soon showed signs of decimation, clumping of cells and cytoplasmic granulation, though sometimes a few transparent cells remained for a few days. These, however, would not resume activity when, afterward, they were fed with the usual serum-Tyrode mixture. Controls (*a*) in serum-Tyrode, and (*b*) in a mixture of 10–20 per cent serum plus 90–80 per cent White's nutrient (in order to exclude a possible toxic effect of the synthetic medium) grew well, multiplied actively and could, in some instances, be maintained up to two months. In these control cultures and also in some other experiments, White's nutrient fluid, as prepared by us, has been very satisfactory as a supplementary medium; but when employed alone, it has proved insufficient to maintain the life and activity of pure populations of macrophages.

The above method is suggested as a most exacting procedure for testing synthetic media on cultured animal cells.

The experiments were done in the Department of Physiology, University of Birmingham.

F. JACOBY
S. J. DARKE

Department of Anatomy,
University College, Cardiff,
and
Department of Physiology,
The Medical School, Birmingham.

April 19.

[1]Jensen, A. B., *Nature*, **161**, 273 (1948).
[2]White, P. R., *Growth*, **10**, 231 (1946).
[3]Jacoby, F., *J. Physiol.*, **90**, 23 P (1937); **93**, 48 P (1938).

Nutritional Requirements of *Drosophila melanogaster*

KNOWLEDGE of the nutritional requirements of *Drosophila* and the provision of a completely synthetic medium are likely to provide the means of obtaining much more detailed and accurate understanding of various aspects of gene action. Accordingly, we have been working for some time to achieve this objective. *Drosophila* normally lives on live yeast, but can be reared successfully on dead brewers' or bakers' yeast under aseptic conditions. Hence the most logical procedure seemed to require the provision of as many as possible of the known or likely nutritional components, and the subsequent addition of various yeast fractions to a basal medium containing these.

The original basal medium had the following composition:

Casein (vitamin free)	0·06 gm.	Aneurin hydrochloride	4 γ
Gelatin (reprecipitated)	0·045 gm.	Riboflavine	6 γ
dl-Tryptophane	0·005 gm.	Nicotinic acid	12 γ
Ergosterol	0·005 gm.	Pyridoxin	12 γ
Cholesterol	0·005 gm.	Biotin	0·2 γ
Dextrin	0·1 gm.	Inositol	1·5 mgm.
Agar	0·1 gm.	Yeast nucleic acid	3·4 mgm.
Water	5 ml.	Calcium pantothenate	12 γ
Tatum[1] salt mixture (1936) 6 mgm.			

At first, we experienced considerable difficulty in obtaining satisfactory sterile cultures. Our present method, however, gives a high proportion of sterile cultures, and is as follows. Eggs laid on agar slabs are collected and washed in air-free 50 per cent alcohol, pipetted into a solution of 5 per cent 'Antiformin' in 10 per cent formalin and agitated for 10 minutes. After settling, 15–20 eggs at a time are removed with sterile pipettes and transferred to individual small tubes containing 50 per cent alcohol. Each group of eggs is passed through two further changes of alcohol, the total time in alcohol being about half an hour. They are then transferred to the culture tubes with sterile pipettes and a minimum quantity of alcohol. The cultures are incubated at 25° C.

Many different yeast fractions have been prepared, but only the most interesting of these are referred to here. The starting material was an autolysate prepared by treating live yeast with ether containing 1 per cent ammonia for four days at 37° C. under reflux. To facilitate filtration of the resulting mass, ethyl alcohol is added to the extent of approximately 25 per cent by volume. The clear filtrate is then dried *in vacuo*. 0·3 gm. of this preparation per culture permits normal development. This appears to be in conflict with the findings of other investigators[1,2], who found an insoluble yeast fraction to be essential for normal growth. This point will be referred to later.

In the course of treatment, we found that the fraction of the autolysate soluble in 90 per cent ethyl alcohol was active only if added in amount much in excess of the quantity expected on the assumption of concentration of the active material by this treatment, indicating the presence of some component sparingly soluble in 90 per cent alcohol.

Precipitation of whole autolysate with basic lead acetate yields a filtrate lacking something essential for normal pupation, but permitting normal larval growth. This suggested[3] that folic acid might be the missing component. Addition of 2 γ per culture to the basal medium plus the basic lead acetate filtrate permits normal development and pupation. Henceforward folic acid was always included in the basal medium.

At this stage, our attention was directed to the claim[2] that choline and *p*-aminobenzoic acid are essential to *Drosophila*. Addition of these two components to the basal medium allows complete though slow development, pupation taking 10–14 days as against the normal 6–7 days. Of the concentrations of these two substances tried, we found 10 mgm. choline and 25 γ *p*-aminobenzoic acid per culture to be most satisfactory. Thereafter, these two substances were also included in the basal medium.

Using this new medium, attempts to isolate the growth-stimulating factor(s) continued. The following is a summary of some of the preparations likely to be of use in the concentration of the active material. Exhaustive extraction of the whole autolysate with ether and/or ethyl alcohol leaves the residue active. There are, however, indications that the active factor may be sparingly soluble in methyl, *n*-butyl or ethyl alcohol. Further experiments are in progress to confirm this. The active factor(s) is freely soluble in concentrations of ethyl alcohol up to 70 per cent; thereafter solubility diminishes. The active material can be extracted from the autolysate with glacial acetic acid, and recovered by precipitation with alcohol and ether. There is also evidence that it is adsorbed on to activated charcoal from slightly acid solution.

As was pointed out above, we do not find that an insoluble fraction is needed. However, the soluble fraction of the autolysate can be replaced completely by the material remaining after exhaustive extraction of whole yeast with 0·2 *N* hydrochloric acid, and also by the insoluble matter remaining after autolysis with ethyl acetate containing 1 per cent ammonia. This is in agreement with the findings of Schultz and Tatum. Parallel with the attempts to isolate the active material from the soluble fraction of the autolysate, we have attempted to do likewise with the insoluble fraction. We have not yet succeeded in doing this. We have, however, obtained some information about its properties. These are briefly as follows. The active material in the insoluble residue from 0·2 *N* hydrochloric acid extraction is neither extracted nor destroyed by Soxhlet extraction with ethyl alcohol, ether, pyridine or glacial acetic acid. Nor is it destroyed by treatment with potassium permanganate or dilute nitric acid. It is destroyed, however, by boiling with 10 per cent or higher concentrations of hydrochloric acid, and by 0·2 *N* sodium hydroxide. It is conceivable, therefore, that the same substance is present both in the insoluble

residue and in the soluble fraction of the autolysate, and that in the former case it is bound in some way to the cell wall.

Further work on the isolation of this factor and its possible identity with the soluble autolysate factor is in progress. Full details will be published elsewhere.

Part of this work was carried out while one of us (M. B.) held a Carnegie Teaching Fellowship at the University of Aberdeen. We wish to thank the Trust for financial assistance.

MICHAEL BEGG
Genetics Department,
University of Edinburgh.
FORBES W. ROBERTSON
Genetics Laboratory of Animal Breeding,
Research and Genetics Organisation,
Edinburgh.
Feb. 3.

[1] Tatum, E. L., *Proc. U.S. Nat. Acad. Sci.*, **25**, 490 (1939).
[2] Schultz, J., St. Lawrence, P., and Newmeyer, D., *Anat. Rec.*, **96**, 540 (1946).
[3] Golberg, L., De Meillon, B., and Lavoipierre, M., *Nature*, **154**, 608 (1944).

Botanical Nomenclature of the Shaddock or Pomelo

POMELO, shaddock, or as it is called in Bengal, batabi nembu or jamboora, is usually known botanically by the name *Citrus decumana* Linn. Swingle adopted the name *Citrus grandis* Osbeck for this plant on grounds of priority[1]. He, however, overlooked another earlier and validly published name of this lemon, which was later pointed out by Merrill[2], and which formed the basis for a new combination under *Citrus*. The name of pomelo is now satisfactorily settled under the rules as *Citrus maxima* (Burm.) Merrill. In a recent publication[3], I found that the name *Citrus grandis* Osbeck is still used and perhaps considered as the correct name of this plant. It is not clearly known whether the author or those who were responsible for the nomenclature of the book took Merrill's name into account or whether this name was merely overlooked. The name *Citrus maxima* is not mentioned even in synonymy. If the name was considered and rejected in favour of *Citrus grandis* Osbeck, there must have been some reason for this. In any event, for the name of such a common Indian plant it is desirable that there should be no confusion, and it is with this object that the present note has been prepared. Before going any further let us consider the correct name, followed by various other names of this plant. The latter group of names are arranged chronologically. We have thus as follows:

Citrus maxima (Burm.) Merrill (l.c.). (i) *Citrus aurantium* Linn. var. *grandis* Linn. Sp. Pl. 783 (1753). (ii) *Aurantium maximum* Burm. ex Rumph. Herb. Amb. Auct. Ind. Univ. [16] (1755). (iii) *Citrus grandis* Osbeck *non* Hassk. Dagbok Ostind Resa, 98 (1757)[4]. (iv) *Citrus aurantium* Linn. var. *decumana* Linn. Sp. Pl. ed. **2**, 1101 (1763). (v) *Citrus decumana* Linn. Syst. Nat. ed. 12, **2**, 508 (1767).

It will be realized from the above list that the names for (i) and (iv), although now listed in synonymy, were originally of varietal rank only. In changing the status, that is, variety to species, the name *Citrus grandis* Osbeck became valid as a specific name only from 1757. According to the rules, in choosing a name as the basis for a new combination the earliest legitimate name or epithet of the *same rank* is to be sought. That is, the names of a species and of a variety (being obviously of different status) cannot be considered together for such a purpose. It will therefore be realized that the names under (i) and (iv) above should be disregarded for the purpose of a new combination. The earliest legitimate name of specific rank is *Aurantium maximum* Burm., which antedates *Citrus grandis* Osbeck by two years. The former name should therefore form the basis for a combination as has been rightly adopted by Merrill. The correct name of pomelo is therefore *Citrus maxima* (Burm.) Merrill.

This question of status is often lost sight of, and it is unfortunate that authors are sometimes misled by the dates of priority alone.

D. CHATTERJEE
c/o Royal Botanic Gardens,
Kew.
April 24.

[1] *Plantæ Wilsonianæ*, **2**, 144 (1914).
[2] Interpr. Herb. Amboin, 296 (1917).
[3] Benthal, "Trees of Calcutta", 88 (1946).
[4] Hasskarl described another plant as *Citrus grandis* Hassk. in *Flora*, **25**, Beibl. **2**, 44 (1842). This plant is considered by Miquel as *Citrus nobilis* Lour. (see *Miq. Fl. Ind. Bat.*, **1**, Pt. 2, 527 : 1859). Hasskarl's name (*Citrus grandis* Hassk.), being a later homonym, becomes invalid under the rules.

Significance of Pollen Dimorphism in Late-Glacial *Armeria*

THE existence of pollen dimorphism in the genus *Armeria* was discovered by Kulczyński[1] during the investigation of *Dryas*-containing beds near Przemyśl in Poland. Iversen[2] showed that in living European material of *A. maritima* (Mill.) Willd., plants with Type *A* and Type *B* pollen are self-incompatible but cross-compatible. However, in the circumpolar variety *sibirica* Lawr.[3], the pollen is monomorphic and the plants are self-compatible. According to Iversen, this may be related to a paucity of pollinating insects.

I have examined numerous herbarium specimens of *A. maritima* from inland mountain habitats in Great Britain. In addition, mass collections made from the populations on the east side of Helvellyn, Westmorland and on Widdy Bank Fell, in Teesdale, have been analysed. All these have shown that the inland populations, like the maritime, are regularly dimorphic. It is probable that the mountain populations are descended from the thrift which was widespread in Britain in late-glacial times, and the pollen-picture shown by fossil remains is therefore of considerable interest.

Through the kindness of Mr. G. F. Mitchell, I have been able to examine a number of calyces washed from a late-glacial clay (containing remains of *Salix herbacea* L. and *S. reticulata* L.) which he collected with Dr. H. Godwin at Whitrig, south Berwickshire. Five of these calyces contained pollen grains and, with one exception, these were only of the Type *B*. The exceptional calyx contained several Type *B* grains (which must have been the type produced by that flower) and a single Type *A* grain near the base. The presence of this last grain strongly indicates that cross-pollination had occurred. It is most unlikely that the grain could have entered while the calyx was lying in the clay, for the examination of this clay has shown *Armeria* grains to be extremely infrequent (an observation which is confirmed by Mr.

Mitchell), and Type *A* grains have not yet been found. Wind-pollination is unlikely in this entomophilous species (which has sticky pollen), especially as vegetative reproduction usually causes a considerable spatial separation of the two types of plant. It appears most likely that insect-pollination had occurred.

Prof. Jessen tells me that he has re-examined the late-glacial (Zone III) material from Ballybetagh, Co. Dublin[4], and early post-glacial (Zone IV) material from Munhin Bridge, Co. Mayo. Some calyces contained one pollen type, others the alternative. Early post-glacial (Zone IV) material from Devil's Bit, Co. Kerry, showed a few grains of Type *A*. Also Dr. Godwin has now found both types of pollen in material from Nazeing, in the Lea Valley. Szafer[5] reported that material from Barnwell, Cambridgeshire (Chandler[6]), was dimorphic, but the dating of these deposits is uncertain.

From the remains at Ballybetagh, Jessen[4] reported fragments of Coleoptera and Trichoptera; but the regular dimorphism and, especially, the results from the Whitrig clay specimens, suggest that insects capable of pollinating the thrift must also have been present in even the colder phases of the Late Glacial in the British Isles.

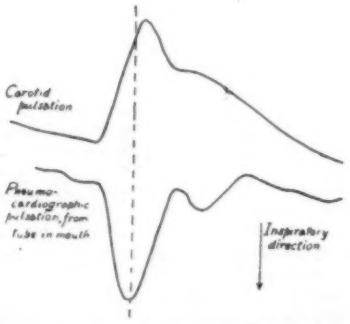
H. G. Baker

Botany Department,
University,
Leeds.
Jan. 31.

[1] Kulczyński, S., *Acta Soc. Bot. Polon.*, **9**, 296 (1932).
[2] Iversen, J., *Kgl. Danske Vidensk. Selskab., Biol. Meddel.*, **15**, 1 (1940).
[3] Lawrence, G. H. M., *Gentes Herbarum*, **4**, 391 (1940).
[4] Jessen, K., and Farrington, A., *Proc. Roy. Irish Acad.*, B. **44**, 205 (1938).
[5] Szafer, W., *Starunia*, **20**, 1 (1945).
[6] Chandler, M. E. J., *Quart. J. Geol. Soc.*, **77**, 4 (1921).

Demonstration of the Heart Beat

In discussing this subject, Dr. Hird states[1] that "the puffs of smoke correspond to cardiac systole". By this it is assumed that coincident with ventricular systole there is an outward or 'expiratory' movement of air through the mouth. That this may not always be the case is shown in the accompanying synchronous tracings of the pneumo-cardiogram and carotid pulsations, from a normal subject in the sitting posture. It will be seen that coincident with the carotid upstroke there is the main wave of the pneumo-cardiogram, and that the direction of this wave is 'inspiratory'.



SYNCHRONOUS TRACINGS OF THE CAROTID PULSE AND A PNEUMO-CARDIOGRAM DURING ONE CARDIAC CYCLE (SUBJECT IN SITTING POSITION)

The explanation of this phenomenon may be that during ventricular systole the expulsion of blood from the thorax causes an 'inspiratory' movement of air into the lungs.

Dr. Hird suggests "it is doubtful if the accurate measurement of these pressure changes would provide any valuable evidence of the condition of the blood vessels". With this one might be in agreement, but as a means of studying the intra-thoracic cardiodynamic events it has been and is proving of great value (see Franz M. Groedel for full review of literature and discussion of mechanisms involved[2]).

Ian F. S. Mackay

Department of Physiology,
Medical School,
University of Durham,
King's College,
Newcastle-upon-Tyne.

[1] Hird, A. J., *Nature*, **161**, 321 (1947).
[2] Groedel, F. M., "The Venous Pulse" (Brooklyn Med. Press, New York, 1946).

Prof. Walter Schlapp, Department of Physiology, University of Manchester, points out that E. Holzlöhner has described the 'cardio-pneumatic movements' and discussed their significance (*Z. Biol.*, **92**, 233 (1932); **97**, 409 (1936)).

Proposed Central Publication of Scientific Papers

In June of this year a Scientific Information Conference is being called by the Royal Society of London, to be attended by representatives of the countries of the British Commonwealth and of the United States[1]. A number of societies which publish scientific journals have already been invited to the Conference, and preliminary drafts of schemes to be discussed have been circulated. Among these is the draft of a provisional scheme for "Central Distribution of Scientific Publications" put forward by Prof. J. D. Bernal, the editor-in-chief of the first of the four sections of the Conference.

This scheme deals in effect with publication as well as with distribution and proposes a radical change in the existing machinery of publication through established scientific journals. This is to be brought about by the creation of "National Distributing Authorities", through which papers would be received and referred to panels of appropriate scientific societies. On acceptance they would be printed by the National Distributing Authorities concerned and distributed according to a detailed scheme.

The implications of this proposed mechanism of publication and distribution of the results of scientific work are so profound and far-reaching that the Society for Freedom in Science considers it necessary at once to direct attention to some of the basic issues involved. The points embodied in the following comments the Society owes to some of its members who have had long experience in the conduct of scientific journals.

(1) The issue of a journal is essential to the coherence and vitality of many scientific societies, especially of those which have a substantial overseas (especially Commonwealth) membership. The issue of bulletins of scientific meetings and the like would not be an adequate substitute.

(2) Many scientific journals play an important part in assisting and educating young scientists. The editors, besides accepting or rejecting manuscripts, often advise modification, suggest alternative explanations and propose consultation of fresh authorities; sometimes they suggest new fields of research. Moreover, they actively seek to secure articles from leading authorities as well as material from fields of research that merit support and development. They are rewarded by association of their names with particular journals of a certain character and quality. If the functions of publishing the results of research were removed from the journals, their discontinuance would inevitably follow and these valuable directive services would be lost.

(3) Editors may, and do, accept and print articles for which there is little current demand, because of potential values which they recognize; the fact that this is done by several journals in any one branch of science affords an important guarantee against the loss of such work—a loss that might well result from centralized editing.

(4) Scientific journals compete with one another. Standards of production, both technical and scientific, consequently tend to be maintained at a high level. Eminent workers are encouraged to publish their views and conclusions, and gaps in the front of scientific advance are thus constantly being filled as the result of a deliberate policy associated with improvement of the journals. Centralization could not replace this process.

(5) It is of fundamental importance that no single person or committee should ever be able to prevent the publication of any scientific paper: whatever its subject may be, there should be at least two independent editors or editorial boards to whom it may be offered. Editing is very much a matter of experience and personal judgment. The existence of several journals within one field of science representing slightly different lines of approach and treatment ensures that good work on varied or novel lines will not be rejected or suppressed.

(6) It is extremely unlikely that editors would continue to undertake all the functions they now discharge, largely without payment and from love of their subject, if their power and prestige were diminished to the extent proposed.

(7) Various technical difficulties, apparent only after long experience of editing, beset the proposals for centralization.

(*a*) *Financial.* It is not perhaps generally appreciated that the current practice is to issue offprints of scientific papers at a price much below their cost. This is a deliberate concession, generally effected by letting the journal bear all overhead costs of composition, correction, block-making, etc. In any scheme to replace the issue of journals by the direct issue of separates, the current average price of separates would have to be very greatly increased.

(*b*) *Administrative.* An outstanding decision which an editor has to make is the number of copies of current issues to be printed, and when the quality of his journal reaches a certain level he can count upon personal and library subscriptions covering 80 per cent or 90 per cent of this number. Save in exceptional cases the number remains relatively constant for considerable periods, or changes only gradually. The position of an organisation selling offprints would be very different. Under the system of 'block subscriptions' in 'units', *plus* supply in response to individual requests, it would be difficult or impossible to gauge the numbers of individual papers actually required.

Editors know that the real demand for separates, apart from the author's, is only felt some months after publication, when the work has been read and its interest recognized. It is impossible either to keep type standing until the demand (spread over months or years) can be assessed or to print enough separates of every paper to meet all possible demands for it.

The 'block subscription' system is supposed to make it possible for all subscribers to get all the papers they wish to see and few in which they are not interested. This system would involve a detailed classification of the different fields of science, a task requiring the most thorough and comprehensive knowledge of current papers as well as of the scientific universe. In many fields of science, especially perhaps the biological, such a classification would, in fact, be impossibly complex, and would certainly result in a subscriber receiving a number of papers he did not want and missing others that he did.

(8) The specialization of existing journals has arisen in response to demands for development of particular scientific interests, and the fields which they cover are well understood. Some are privately owned, many belong to scientific societies. The freedom to initiate new publications of this sort is part of the heritage of scientific freedom.

(9) The initial printing of papers in journals has many advantages. It enables people to see and read in libraries papers which they do not necessarily wish to possess, and is in this way one of the few forces still acting against the excessive concentration of many research workers on their narrow speciality. It is also a safe guarantee against dispersion and loss to which separates are liable.

(10) The desire to make all separates in any scientific subject easily available to those who do wish to possess them is perfectly legitimate and ought to be met. It should be possible to make photographic reproductions of individual papers (by microfilm or otherwise) available at some fixed time (say, three months) after publication in a journal, and to issue them under the legal control of the publishers of the journal. Such a system should be coupled with the development of a service making known the contents of journals immediately after they appear, as is to be proposed in other sections of the Conference.

(11) Scientific publication is a natural and indispensable sequel to scientific investigation, the two together forming an indivisible process which rests essentially on the individual freedom of men of science to work, write and publish as they choose within the powers they recognize as their own. The scheme for centralized printing and issue of scientific papers seems to threaten these rights to scientific freedom very directly and to involve a great overall loss of efficiency, despite its claims to increase it.

G. P. THOMSON
(President)
JOHN R. BAKER
(Hon. Secretary)

Society for Freedom in Science,
(Hon. Sec.,
Department of Zoology,
University Museum,
Oxford).

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THEORY OF THE STRUCTURE OF CLAY MINERALS

TAILED X-RAY REFLEXIONS FROM RANDOM LAYER LATTICES

SOME substances, such as chrysotile and graphite, appear to possess a layer structure in which the comparatively perfect layers are displaced by amounts that are either random (graphite) or effectively random for some reflexions (chrysotile). In the reciprocal-space representation, these reflexions are represented by rods perpendicular to the layers, the cross-section of the rods depending on the size of the layers, and the variation of intensity along them depending on the variation of the structure amplitude of a single layer. Warren[1] has calculated the line profile of such reflexions on powder photographs, replacing the true variation of intensity across the rod by a Gaussian distribution. Patterson[2] has shown in the related problem of line-broadening by small particles that this is not a very good approximation, and it therefore seemed desirable to derive expressions for the line profile without the use of it.

The intensity of reflexion from a crystal is

$$I(\mathbf{H}) = \Sigma_j \Sigma_{j'} F_j F^*_{j'} \exp\{2\pi i(\mathbf{r}_{j'} - \mathbf{r}_j) \cdot \mathbf{H}\}, \quad (1)$$

where $\mathbf{H}$ is the position vector in reciprocal space and F_j and $\mathbf{r}_j$ are the structure amplitude and position vector of the jth unit cell[3]. For reflexions for which the phase relation between successive layers is effectively random, the intensity will be simply N times that of a single layer, where N is the number of layers, and equation 1 becomes

$$I(\mathbf{H}) = N \Sigma_{j_1} \Sigma_{j_2} \Sigma_{j_1'} \Sigma_{j_2'} F_j F^*_{j'} \exp\{2\pi i(\mathbf{r}_{j'} - \mathbf{r}_j) \cdot \mathbf{H}\}, \quad (2)$$

where $\mathbf{r}_j$ is now the position vector within a layer. The intensity will be large when

$$\mathbf{H} = h\mathbf{a}' + k\mathbf{b}' + w\mathbf{c}', \quad (3)$$

where $\mathbf{c}'$ is a unit vector perpendicular to the layers, $\mathbf{a}'$ is of length $1/a \sin\gamma$ and perpendicular to $\mathbf{b}$ and $\mathbf{c}'$, $\mathbf{b}'$ is of length $1/b \sin\gamma$ and perpendicular to $\mathbf{a}$ and $\mathbf{c}'$, h and k are integers, and w is arbitrary. (In general, $\mathbf{a}'$ and $\mathbf{b}'$ do not coincide with $\mathbf{a}^*$ and $\mathbf{b}^*$.) Let $\mathbf{H} = \mathbf{S}_0 + \boldsymbol{\rho}$, where $\mathbf{S}_0 = h\mathbf{a}' + k\mathbf{b}'$, and let $(x,y),(u,v)$ be the components of $\mathbf{r}$ and $\boldsymbol{\rho}$ in the direction of $\mathbf{S}_0$ and in the direction perpendicular to $\mathbf{S}_0$ and $\mathbf{c}'$. Then in equation (2) $\mathbf{r}_j \cdot \mathbf{S}_0$ is an integer, and may be dropped from the exponentials, and $\mathbf{r}_j \cdot \boldsymbol{\rho}$ changes only slightly in going from one unit cell to the next, so that the summations may be replaced by integrations over the area of the layer. Then

$$I(u,v,w) = NF^2(w)cC^{-1} \int_{A'} \int_{A} \exp\{2\pi i[(x'-x)u + (y'-y)v]\} dA dA', \quad (4)$$

where C is the area of the face of the unit cell containing $\mathbf{a}$ and $\mathbf{b}$, and c is the interlayer spacing. Except for certain geometrical factors, the intensity of reflexion as a function of $S = 2\sin\theta/\lambda$ is got by integrating $I(u,v,w)$ over the space between two spheres of radii S and $S + dS$, but to a sufficient approximation these may be replaced by tangent paraboloids. The equation of the paraboloid making the closest contact with the sphere $S^2 = \mathbf{H}.\mathbf{H} = S_0^2 + 2uS_0 + u^2 + v^2 + w^2$ in the important region $u,v \sim 0$ is

$$S^2 = S_0^2 + 2uS_0 + w^2. \quad (5)$$

Let $\sigma = (S^2 - S_0^2)/2S_0$. The intensity of reflexion as a function of σ is given by the integral of $I(u,v,w)$ $dudvdw$ over the space between the two spheres or, since the volume element $dudvdw$ corresponds to $dvdwd\sigma$, by

$$I(\sigma)d\sigma = NcC^{-1} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \int_{A'} \int_{A} F^2(w) \exp\{2\pi i[(x'-x)\sigma - (x'-x)w^2/2S_0 + (y'-y)v]\} dA dA' dv dw d\sigma. \quad (6)$$

The integrals with respect to v and y' are singular, the double integral giving

$$I(\sigma) = NcC^{-1} \int_{-\infty}^{+\infty} \int_{x'} \int_{A} F^2(w) \exp\{2\pi i[(x'-x)\sigma - (x'-x)w^2/2S_0]\} dA dx' dw,$$

or, with $x' - x = t$ and $A(t) = \int\int dxdy$ over the area common to the layer and its 'ghost' shifted a distance t parallel to $\mathbf{S}_0$ (compare ref. 4, p. 37),

$$I(\sigma) = NcC^{-1} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} F^2(w) A(t) \exp\{2\pi i[\sigma t - w^2 t/2S_0]\} dw dt. \quad (7)$$

If the variation of F^2 with w be neglected, the integration with respect to w is of the Fresnel type, giving

$$I(\sigma) = NF^2cC^{-1} (S_0/2)^{1/2} \int_{-\infty}^{+\infty} A(t) |t|^{-1/2} (\cos 2\pi\sigma t + \sin 2\pi\sigma |t|) dt. \quad (8)$$

This is analogous to the expression for the line profile for a normal hkl reflexion from a small crystal,

$$I(s) = F^2U^{-1} \int_{-\infty}^{+\infty} V(t) \cos 2\pi st dt, \quad (9)$$

where $s = S - S_0$ and $V(t)$ is the volume common to the crystal and its 'ghost' shifted a distance t perpendicular to the hkl planes (ref. 4, p. 41; ref. 5). The apparent particle size for the normal reflexion (equation 9) is easily obtained in the form

$$\mathfrak{t} = V^{-1} \int V(t) dt, \quad (10)$$

but no corresponding expression can be obtained for the tailed reflexion (equation 8), since (i) $\int I(\sigma)d\sigma$ does not converge, and (ii) the position and height of the maximum of $I(\sigma)$ cannot be expressed in simple form. The nearest analogue is perhaps the ratio of the slope $\partial I/\partial\sigma$ to the actual value of $I(\sigma)$ for $\sigma = 0$:

$$\mathfrak{t}' = 2\pi \int_{-\infty}^{+\infty} A(t) |t|^{1/2} dt \Big/ \int_{-\infty}^{+\infty} A(t) |t|^{-1/2} dt. \quad (11)$$

This may be evaluated for simple layer shapes; for a square, with sides of length X making angles with $\mathbf{S}_0$ the positive values of the cosines of which are $m \geqslant n$, it is

$$\mathfrak{t}' = 2\pi X(7m - 3n)/7m(5m - n) \doteqdot 1{\cdot}26\, X, \quad (12)$$

and for a circle of diameter D it is

$$\mathfrak{t}' = \frac{3\pi D}{10} \left[\frac{\Gamma(5/4)}{\Gamma(7/4)}\right]^2 \doteqdot 0{\cdot}924\, D \doteqdot 1{\cdot}04\sqrt{(\pi D^2/4)}. \quad (13)$$

For σ large and positive, equation (8) approaches

$$I(\sigma)d\sigma = NF^2cC^{-1}A(2S_0)^{1/2}\,\sigma^{-1/2}\,d\sigma,$$
$$I(S)dS = NF^2cC^{-1}A.\,2S(S^2 - S_0^2)^{-1/2}\,dS, \qquad (14)$$

where A is the area of a layer; and for σ large and negative it is zero. For small σ, equation (8) may be expanded as a power series in $\sigma\,|\,t\,|$ and integrated term by term for values of $A(t)$ corresponding to various layer shapes. Preliminary results indicate differences of a few per cent from Warren's curve, especially for σ negative.

Without a knowledge of the crystal structure it appears difficult to take the variation of F^2 with w into account in evaluating the line profile. From an experimental knowledge of the line profile it might be possible to work back to the crystal structure; a Fourier transformation applied to equation (7) leads to

$$\int_{-\infty}^{+\infty} F^2(w)\,\exp\{-\pi i w^2 t/S_0\}\,dw =$$
$$\frac{C}{NcA(t)}\int_{-\infty}^{+\infty} I(\sigma)\,\exp\{-2\pi i\sigma t\}\,d\sigma, \qquad (15)$$

the left-hand side of which is easily expressed in terms of h, k, t and the atomic co-ordinates. The x and y components of the interatomic vectors appear linearly, but the z components occur squared.

This work forms part of an investigation of the diffraction of X-rays by imperfect structures, for which an apparatus grant has been received from the Royal Society.

A. J. C. Wilson

Viriamu Jones Laboratory,
University College,
Cardiff.
Dec. 2.

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BANDED X-RAY REFLEXIONS FROM CLAY MINERALS

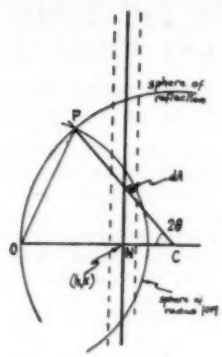
The banded character of many of the X-ray 'lines' from such clay minerals as montmorillonite and halloysite has been attributed to their structures being equivalent to a random stacking of two-dimensional silicate sheets[1]. The relevant theory has been developed by Warren[2], who introduced simplifying assumptions in order to obtain explicit expressions for the intensity distribution. We have sought a more general expression than Warren gives, and have avoided certain of his approximations by expressing the results in a form requiring numerical integration.

A finite two-dimensional crystal with axes a_1 a_2 is represented in reciprocal space, R-space, by a lattice with axes b_1b_2, the points of which are diffused *parallel* to the b_1b_2 plane in a manner depending on the crystal size and shape, and *normal* to this plane in accordance with the cell structure-factor F. The diffracted intensity is determined by the intersection in R-space of the sphere of reflexion with these diffused lines. Allowance must also be made for the fact that powders and not single crystals are used.

For an infinite two-dimensional crystal sheet of periodic electron density $\rho_\infty(a)$, (Ewald's notation[3]), the Fourier transform consists of straight lines hk of linear density $F(b)/A_a$, where $F(b)$ is the structure factor and A_a is the cell area. For a finite crystal of shape $s(a)$,

$$\rho_s(a) = \rho_\infty(a)\,s(a),$$

and the Fourier transform of $\rho_s(a)$ is $F(b)\,S(b)/A_a$. The shape transform, $S(b)$, is the diffraction pattern of $s(a)$, which for two-dimensional crystal flakes is the diffraction pattern observed optically. FS/A_a represents the scattered X-ray amplitude, and the corresponding intensity expression is FF^*SS^*/A_a^2, where * signifies the conjugate complex.



The diagram represents the diffused line associated with a lattice point N in R-space and shows the condition for reflexion in direction CP, where P is a point on the sphere of reflexion of radius $1/\lambda$. For randomly arranged crystals, the average reflected intensity is obtained by averaging over a sphere of radius $|\,OP\,| = 2\sin\theta/\lambda$, and is equal to

$$\Big[\int FF^*SS^*dA\Big]/A_a^2\;4\pi(2\sin\theta)^2/\lambda^2,$$

where dA represents a surface element of the sphere of radius $|\,OP\,|$. This has to be multiplied by the usual electronic and polarization factors,

$$\frac{e^4 I_0}{m^2c^4}\left(\frac{1+\cos^2 2\theta}{2}\right).$$

If $dE(2\theta)$ is the energy reflected between directions 2θ and $2(\theta + d\theta)$, that is, in $dw = 4\pi\sin 2\theta.d\theta$, then the reflected intensity $I(2\theta) = dE/4\pi\sin 2\theta.d\theta$ and $dE/d(2\theta) = 2\pi I(2\theta)\,.\,\sin 2\theta$. Only a fraction $1/2\pi R\sin 2\theta$ of this energy is recorded per unit length of line in a camera of radius R. Thus the reflected energy in angular range $d(2\theta)$ per unit length of line on the film is given by

$$\frac{dE}{d(2\theta)} = \frac{I_0e^4\lambda^2}{m^2c^4RA_a^2}\left(\frac{1+\cos^2 2\theta}{32\,\pi\sin^2\theta}\right)\int FF^*SS^*\,dA. \quad (1)$$

The integral in this expression can be calculated numerically for crystal flakes of simple shape and of known layer structure. A close approximation to integration over the spherical surface is obtained by replacing the sphere by a series of thin cylindrical strips running parallel to the b_1b_2 plane. Provided FF^* does not vary greatly across the diffused line in R-space, then FF^* may be treated as constant for integration along each cylindrical strip. With simple crystal shapes an algebraic solution of $\int SS^*dA$ may be obtained for each strip integration; the results of these calculations will be published shortly. For the complete integration, however, the variation of FF^* along the diffused line in R-space

must be taken into account when the crystalline layer has a structure such as we find in the clay minerals.

When the sphere of radius $|OP|$ cuts the diffused line far from the b_1b_2 plane, we can write approximately

$$\int FF^*SS^*dA = FF^* \int SS^* dA'/\sin\alpha.$$

Here dA' is the projection of dA on to a plane through P parallel to the b_1b_2 plane, and α is the angle POC. If we put ON (see diagram) equal to $2\sin\theta_0/\lambda$, then $\sin\alpha = (\sin^2\theta - \sin^2\theta_0)^{1/2}/\sin\theta$, and since quite generally $\int SS^*dA' = NA_a$, where N is number of cells per crystal, we obtain at once

$$\frac{dE}{d(2\theta)} \doteq \frac{I_0e^4}{m^2c^4RA_a}\left(\frac{1+\cos^2 2\theta}{32\pi\sin\theta}\right)\frac{FF^*}{(\sin^2\theta - \sin^2\theta_0)^{1/2}}$$

valid for $\theta \gg \theta_0$, which is exactly the expression given by Warren.

G. W. BRINDLEY

Physics Laboratories,
University, Leeds.

J. MÉRING

Laboratoire Central des Services
Chimiques de l'État,
Paris.
Dec. 18.

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INHERITANCE OF SEX FORMS IN *LUFFA ACUTANGULA* ROXB.

By H. B. SINGH, S. RAMANUJAM
AND
B. P. PAL

Division of Botany, Indian Agricultural Research Institute, New Delhi

SEX habit in plants is known to be controlled by genetic factors, although subject to environmental fluctuations. Poole and Grimball[1], working on the inheritance of certain new sex forms in *Cucumis melo*, a member of the Cucurbitaceæ, have reported that the hermaphrodite form is genetically a double recessive to monœcious, and in F_2 populations from crosses between them the following phenotypic ratio was obtained—9 monœcious : 3 andromonœcious : 3 gynomonœcious : 1 hermaphrodite. The gynomonœcious type was, however, susceptible to environmental fluctuation, giving rise occasionally to gynœcious and trimonœcious forms. On the basis of these results they have designated the several sex forms in their material as follows: monœcious (AG), andromonœcious (aG), gynomonœcious (Ag) and hermaphrodite (ag).

Inheritance studies of sex forms in *Luffa acutangula*, another member of the Cucurbitaceæ, have been in progress at the Indian Agricultural Research Institute, New Delhi, for the last four years, and a preliminary account of the results obtained is presented in this note.

L. acutangula is ordinarily a monœcious species, although a hermaphrodite form, locally named salputya, is known to be cultivated as a vegetable in Bihar. In the year 1943, in the garden of one of the residents of the Institute, a crop of this species was found to contain a few hermaphrodite and andromonœcious plants besides a majority of monœcious plants. In the monœcious plants the male flowers are in a raceme while the female flowers are borne singly in the axils of leaves. The flowers in the hermaphrodite forms are borne in clusters of 10–20, about 50 per cent of which set fruits. In the andromonœcious type, the perfect flowers are borne singly like the female flowers of the monœcious plant. The three types, on self-pollination, were found to be true breeding. Figs. 1–4 illustrate inflorescences of the three sex forms and of a gynœcious type which appeared in one of the crosses.

Crosses were made between the three sex forms in all combinations, and the results are given below. The symbols used to designate the various types are explained later in the note.

(1) *Monœcious* ($AAGG$) × *Hermaphrodite* (a^1a^1gg). F_1 plants (Aa^1Gg) were monœcious. The F_2 segregation of sex types, which indicated the interaction of two pairs of factors, was as follows:

Fig. 1. MONŒCIOUS

Fig. 2. ANDROMONŒCIOUS

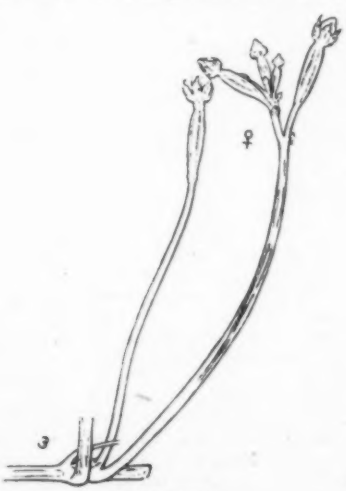

Fig. 3. GYNŒCIOUS

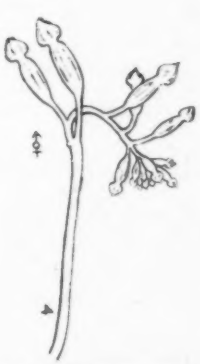

Fig. 4. HERMAPHRODITE

	Observed	Expected (9:3:3:1)	
Monœcious (*AG*)	142	129·6	*P* between 0·3 and 0·2. The fit is good.
Andromonœcious (a^1G)	36	43·2	
Gynœcious (*Ag*)	42	43·2	
Hermaphrodite (a^1g)	10	14·4	

A number of F_2 populations raised from selected F_2 plants representing the different classes supported the hypothesis of two-factor inheritance.

(2) *Monœcious* (*AAGG*) × *Andromonœcious* (a^1a^1GG). F_1 plants (Aa^1GG) were monœcious. In the F_2, monœcious and andromonœcious types segregated in the ratio of 3 : 1 as under :

	Observed	Expected (3:1)
Monœcious (*AG*)	23·0	22·5
Andromonœcious (a^1G)	7·0	7·5

(3) *Hermaphrodite* (a^1a^1gg) × *Andromonœcious* (a^1a^1GG). F_1 plants (a^1a^1Gg) were andromonœcious. In the F_2, andromonœcious and hermaphrodite segregated in the ratio of 3 : 1 as stated below :

	Observed	Expected
Andromonœcious (a^1G)	17	18
Hermaphrodite (a^1g)	7	6

The two-factor inheritance obtained in the above crosses was further confirmed by the following test crosses :

(1) Monœcious (*AAGG*) × Hermaphrodite (a^1a^1gg) × Monœcious (*AAGG*). The progeny (*AAGG*, *AAGg*, Aa^1GG, Aa^1Gg) was all monœcious.

(2) Monœcious (*AAGG*) × Hermaphrodite (a^1a^1gg) × Hermaphrodite (a^1a^1gg). The progeny segregated in the ratio of 1 monœcious (Aa^1Gg) : 1 andromonœcious (a^1a^1Gg) : 1 gynœcious (Aa^1gg) : 1 hermaphrodite (a^1a^1gg).

(3) (i) Gynœcious (*AAgg*) × Monœcious (*AAGG*). The progeny was all monœcious. (ii) Gynœcious (Aa^1gg) × Monœcious (*AAGG*). The progeny was all monœcious.

(4) (i) Gynœcious (*AAgg*) × Andromonœcious (a^1a^1GG). The progeny was all monœcious. (ii) Gynœcious (Aa^1gg) × Andromonœcious (a^1a^1GG). The progeny consisted of monœcious and andromonœcious in the ratio of 1 : 1.

(5) (i) Gynœcious (*AAgg*) × Hermaphrodite (a^1a^1gg). The progeny consisted of all gynœcious plants. (ii) Gynœcious (Aa^1gg) × Hermaphrodite (a^1a^1gg). The progeny consisted of equal proportions of gynœcious and hermaphrodite plants.

It is clear from the foregoing results that two pairs of factors are involved in the inheritance of sex forms in the various crosses. There is, however, an interesting difference between the phenotypic segregation observed by Poole and Grimball and that obtained by us in the F_2 population of the cross between monœcious and hermaphrodite. While the former obtained 9 monœcious : 3 andromonœcious : 3 gynomonœcious : 1 hermaphrodite in the F_2, our population showed 9 monœcious : 3 andromonœcious : 3 gynœcious : 1 hermaphrodite ; the gynomonœcious form in their material was replaced by gynœcious in our F_2 population. Furthermore, unlike the gynomonœcious type of Poole and Grimball, the gynœcious type was stable and did not show any environmental variations. It would appear, therefore, that the gynœcious form is a definite genotype different from that of the gynomonœcious.

On the basis of these results it seems reasonable to suppose that two gene loci each with a multiple allelomorphic series (A-a^1-a and G-g^1-g) are concerned in the inheritance of the sex forms in *Luffa*. Thus, the various possible sex forms may be tentatively designated as : Monœcious *AG*, Andromonœcious a^1G, Andrœcious *aG*, Gynomonœcious Ag^1, Gynœcious *Ag*, Hermaphrodite *ag*, a^1g^1, a^1g and ag^1.

The above tentative genic hypothesis is in accord with the results obtained in the various crosses studied by us. It also provides an explanation for the different phenotypic segregations in the F_2 of the cross between monœcious and hermaphrodite, observed in our material and that of Poole and Grimball. It is likely that the genotype of the hermaphrodite form used in crosses with monœcious by Poole and Grimball was of the constitution $a^1a^1g^1g^1$, in which case the F_2 segregation would give 9 monœcious (*AG*), 3 andromonœcious (a^1G), 3 gynomonœcious (Ag^1) and 1 hermaphrodite (a^1g^1).

We have not so far come across andrœcious and gynomonœcious forms nor a dioecious species of *Luffa* ; but it is possible that they may be found in the future when further investigations will be undertaken to confirm or modify the hypothesis proposed in this note.

We are indebted to Dr. N. Parthasarathy, geneticist, Indian Agricultural Research Institute, for reading through the manuscript and making some useful suggestions.

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PLANT VIRUS RESEARCH AT CAMBRIDGE

By Dr. KENNETH M. SMITH, F.R.S.
Plant Virus Research Unit, Molteno Institute, Cambridge

ON April 29, at an informal gathering in Cambridge, the new field laboratory of the Plant Virus Research Unit of the Agricultural Research Council was inaugurated, and demonstrations illustrating the principal researches carried out there were staged.

The ceremony also marked the twenty-first anniversary of the establishment at Cambridge of the Plant Virus Research Station, which has now become a research unit of the Agricultural Research Council. The project was started in 1927 under the auspices of the Ministry of Agriculture, and Dr. R. N. Salaman was appointed its first director with the present writer as senior research assistant. The scheme had a two-fold object : (1) to build up nucleus stocks of virus-free potatoes by propagating them in insect-proof glasshouses, and (2) to undertake research, in the first instance, into the virus diseases of the potato plant and their means of spread in the field. As time went on, however, the maintenance of the nucleus stocks of virus-free potatoes became a routine measure and the work was expanded to cover many aspects of plant virus research. Now, with the establishment of the research unit, the virus-free stocks are being handed into the care of the National Institute of Agricultural Botany, which will continue their propagation under glass while maintaining large stocks in strict isolation in the open.

As the importance of virus diseases of plants gradually became recognized, so the work developed, and increasing interest in the activities of the station was taken by workers abroad. Since, with the

exception of Rothamsted Experimental Station and a few centres in the United States, there existed no other laboratory where experience in so many aspects of plant virus study could be obtained, applications from foreign workers for this training became very frequent. Unfortunately, these activities had to be severely curtailed owing to the lack of laboratory accommodation. Nevertheless, it may be mentioned that students have come to take either research degrees or courses of instruction in plant virus work from Argentina, Australia, Belgium, Brazil, Canada, China, Czechoslovakia, Denmark, Gold Coast, India, New Zealand, Poland, Portugal, South Africa, Sweden and the United States, and visitors have come from all over the world.

In looking back over two decades, it becomes evident how, with increasing knowledge and new technical discoveries, the trend of virus research has changed. In the beginning, most of the emphasis was placed on the disease, and symptomatology was all-important, although the study of the relationships between the viruses and their insect vectors was already being undertaken. The isolation of tobacco mosaic virus by Stanley in 1935, however, was the key which opened the door to the study of the virus itself, quite apart from the disease it may cause. A brief review of some of the main contributions by the Cambridge workers illustrates this change of emphasis in virus research. For the first few years, attention was directed almost entirely towards potato virus diseases, and from this work three items of interest may be noted. The first of these was the identification of the insect vector of potato leaf-roll, which was later also found to carry another potato virus. This was the aphis, *Myzus persicæ*, and it was almost the first introduction to public notice of the aphis which, since that time, has become of paramount importance in the field of plant viruses and seems to be the most efficient vector of these agents in the world. It is now known to transmit more than twenty distinct viruses. The next addition to our knowledge of potato viruses was the discovery of the paracrinkle virus in potatoes of the variety King Edward; this is one of the unsolved puzzles of the virus world, since it is present in all plants of this potato variety, but no method is known by which it can spread in Nature. The case of paracrinkle is often quoted as evidence of the heterogenesis of viruses by those who hold this view. The third item was the analysis, for the first time, of a plant virus complex by differential methods of transmission, and the isolation of the two potato viruses now universally known as *X* and *Y*.

In 1931 the virus of tomato spotted wilt was discovered for the first time in Europe; it was found in an ornamental plant sent to Cambridge from Cardiff. Before this it had not been seen outside Australia. Since then the distribution of the virus has become world-wide, and in Great Britain it is one of the major problems of the tomato grower with 'mixed houses'.

The viruses of tomato bushy stunt and tobacco necrosis, both described for the first time in Cambridge, have proved of great scientific interest. The virus of tomato bushy stunt, about which more is known than of most viruses, was the first to be isolated in a three-dimensional crystalline form, and this was accomplished by Bawden and Pirie, after the former had left Cambridge. Shortly after this the virus of tobacco necrosis was isolated as thin crystalline plates. About this time, also, the comparatively new technique of plant virus serology was applied to the study of potato virus *X*.

In 1938 a new virus complex affecting the tobacco plant, known as 'rosette', was investigated, the chief point of interest being the apparent relationship between the two component viruses. This is suggested by the fact that, while both viruses are aphis-transmitted if they are together in the plant, one of the two cannot be picked up by the insect if the other virus is not present.

During the period 1940–45, several new viruses have been described, those of *Arabis*, *belladonna* and lovage mosaic, tobacco broken ringspot, tomato black ring and of two new potato diseases, veinal necrosis and veinal yellows, which were found in some South American potatoes. Of these new viruses, those of *Arabis* mosaic and broken ringspot are of especial interest, since they appeared in plants inside the experimental glasshouses with no apparent explanation of their origin.

During the last two years an extremely interesting and important new virus has been discovered and studied. Known as turnip yellow mosaic virus, it has been isolated in two different crystalline forms and, like other plant viruses studied so far, it is a nucleoprotein. In addition to the active virus, infected plants also contain a protein which is apparently the virus protein but lacks the nucleic acid. This protein has also been crystallized, and studies of the biological and biophysical properties of these two proteins are now in progress. The virus is also of interest in having an entirely new kind of insect vector, one with biting mouthparts, namely, a flea-beetle. This is the first record, both of transmission of a virus by this insect and of the insect transmission of a crystalline plant virus.

Electron microscope studies in conjunction with Dr. V. E. Cosslett of the Cavendish Laboratory, and with Dr. R. W. G. Wyckoff in the United States, have also been made [see p. 760 of this issue of *Nature*]. An interesting outcome of this work is that the structure of the crystals of tobacco necrosis virus and turnip yellow mosaic virus has been demonstrated by this means.

A NEW MICROSCOPIC PRINCIPLE

By Dr. D. GABOR
Research Laboratory, British Thomson-Houston Co., Ltd., Rugby

IT is known that the spherical aberration of electron lenses sets a limit to the resolving power of electron microscopes at about 5 A. Suggestions for the correction of objectives have been made; but these are difficult in themselves, and the prospects of improvement are further aggravated by the fact that the resolution limit is proportional to the fourth root of the spherical aberration. Thus an improvement of the resolution by one decimal would require a correction of the objective to four decimals, a practically hopeless task.

The new microscopic principle described below offers a way around this difficulty, as it allows one to dispense altogether with electron objectives. Micrographs are obtained in a two-step process, by electronic analysis, followed by optical synthesis, as in Sir Lawrence Bragg's 'X-ray microscope'. But

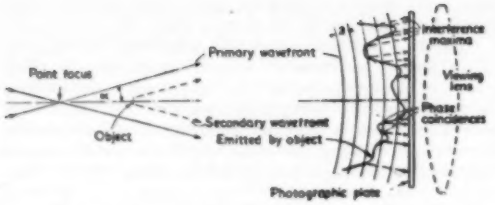

Fig. 1. Interference between homocentric illuminating wave and the secondary wave emitted by a small object

while the 'X-ray microscope' is applicable only in very special cases, where the phases are known beforehand, the new principle provides a complete record of amplitudes *and* phases in one diagram, and is applicable to a very general class of objects.

Fig. 1 is a broad explanation of the principle. The object is illuminated by an electron beam brought to a fine focus, from which it diverges at a semi-angle α. Sufficient coherence is assured if the nominal or Gaussian diameter of the focus is less than the resolution limit, $\lambda/2 \sin \alpha$. The physical diameter, determined by diffraction and spherical aberration of the illuminating system, can be much larger. The object is a small distance behind (or in front of) the point focus, followed by a photographic plate at a large multiple of this distance. Thus the arrangement is similar to an electron shadow microscope; but it is used in a range in which the shadow microscope is useless, as it produces images very dissimilar to the original. The object is preferably smaller than the area which is illuminated in the object plane, and it must be mounted on a support which transmits an appreciable part of the primary wave. The photographic record is produced by the interference of the primary wave with the coherent part of the secondary wave emitted by the object. It can be shown that, at least in the outer parts of the diagram, interference maxima will arise very nearly where the phases of the primary and of the secondary wave have coincided, as illustrated in Fig. 1.

Fig. 2. (*a*) Original micrograph, 1·4 mm. diameter. (*b*) Micrograph, directly photographed through the same optical system which is used for the reconstruction (*d*). Ap. 0·04. (*c*) Interference diagram, obtained by projecting the micrograph on a photographic plate with a beam diverging from a point focus. The letters have become illegible by diffraction. (*d*) Reconstruction of the original by optical synthesis from the diagram at the left. To be compared with (*b*). The letters have again become legible

If this photograph is developed by reversal, or printed, the loci of maximum transmission will indicate the regions in which the primary wave had the same phase as the modified wave, and the variations of the transmission in these loci will be approximately proportional to the intensity of the modified wave. Thus, if one illuminates the photographic record with an optical imitation of the electronic wave, only that part of the primary wave will be strongly transmitted which imitates the modified wave both in phases and in amplitudes. It can be shown that the 'masking' of the regions outside the loci of maximum transmission has only a small distorting effect. One must expect that looking through such a properly processed diagram one will see behind it the original object, as if it were in place.

The principle was tested in an optical model, in which the interference diagram was produced by monochromatic light instead of by electrons. The print was replaced in the apparatus, backed by a viewing lens which admitted about $\sin \alpha = 0{\cdot}04$, and the image formed was observed and ultimately photographed through a microscope. It can be seen in Fig. 2 that the reconstruction, though imperfect, achieves the separation of some letters which could just be separated in direct observation of the object through the same optical system. The resolution is markedly imperfect only in the centre, where the circular frame creates a disturbance. Other imperfections of the reconstruction are chiefly due to defects in the microscope objectives used for the production of the point focus, and for observation.

It is a striking property of these diagrams that they constitute records of three-dimensional as well as of plane objects. One plane after another of extended objects can be observed in the microscope, just as if the object were really in position.

Racking the microscope through and beyond the point focus, one finds a second image of the original object, in central-symmetrical position with respect to the point focus. The explanation is, briefly, that the photographic diagram cannot distinguish positive and negative phase shifts with respect to the primary wave, and this second image corresponds to the same phase shifts as the original, but with reversed sign.

If the principle is applied to electron microscopy, the dimensions in the optical synthetizer ought to be scaled up in the ratio of light waves to electron waves, that is, about 100,000 times. One must provide an illuminating system which is an exact optical imitation of the electronic condenser lens, including its spherical aberration. To avoid scaling-up the diagram, one has to introduce a further lens, with a focal length equal to the distance of the object from the photographic plate in the electronic device, in such a position that the plate appears at infinity when viewed from the optical space of the point focus. Work on the new instrument, which may be called the 'electron interference microscope', will now be taken in hand.

I wish to thank Mr. I. Williams for assistance in the experiments, and Mr. L. J. Davies, director of research of the British Thomson-Houston Company, for permission to publish this note.

AGRICULTURAL AND RELATED PRODUCTS OF THE BRITISH COLONIES

THE Colonial Primary Products Committee was set up in May 1947 "to review, commodity by commodity, the possibility of increasing Colonial production, having regard on one hand to the interests of the Colonial Empire, and, on the other hand, to the present and prospective world needs and the desirability of increasing foreign exchange resources".

An interim report has now been published (Colonial No. 217. H.M. Stationery Office, 1948. 6*d*. net); but although the recommendations put forward are regarded as preliminary only, much useful ground has been covered and the possibilities for increased production in the long term seem encouraging. Further consultation with the Colonial Governments or special missions of inquiry will, however, probably be needed before the suggestions can safely be developed into concrete schemes. The Committee has been fully alive to the difficulties confronting it, and stresses the fact that the matter is more complex than the public generally realizes, for development is inevitably a gradual process and immediate spectacular results are unlikely. To put the matter in proper perspective, the question of increasing production is first reviewed in general terms, so that the requirements and possibilities may be more fairly assessed and some of the many limiting factors better understood. Colonial production needs to be increased not merely as a means of meeting the immediate 'dollar' emergency, but also as a long-term contribution to the stability of the 'sterling area' and to European reconstruction. Supplies of foodstuffs and raw materials must be developed outside the western hemisphere if the pattern of world trade is to be restored to equilibrium; and the capability of the United Kingdom to supply goods for export to meet Colonial demands in full is an essential feature of this economic plan.

The difficulties likely to be encountered on attempting large-scale expansion are various. The encouragement of one industry, for example, may only be feasible at the expense of another, and priorities may have to be drawn up in particular areas. Capital equipment such as communications, public utilities, industrial plant and agricultural machinery are lacking, and until they can be procured any real progress is impossible. The introduction of mechanization, however, may have social and political implications which are not generally recognized. The economic structure of the African Colonies, for example, is based on individual small holdings, and a sudden attempt at large-scale production might have catastrophic results. An intermediate phase of group farming by peasant cultivators on a co-operative basis is put forward as a tentative suggestion.

Lack of local skilled labour is a further serious obstacle, though this should slowly become less of a difficulty as development proceeds. To some extent, however, progress will introduce new problems. The resulting rise in prosperity and living standards at which the Colonial policy aims will increase the local consumption of foodstuffs, so that it cannot be assumed that greater production will always lead to exportable surpluses. Finally, a market for a reasonable period of years, at a fair, remunerative price, must be assured, or the necessary incentive to any effective large-scale expansion in production will be lacking.

The commodities studied were divided into five groups: animal products, food grains, industrial fibres, citrus fruits, and fertilizers. The world shortage of meat is acute, and though at first sight the African Colonies seem to be a very promising region in which to establish an export trade, the widespread occurrence of rinderpest disease at present forms an insuperable obstacle to such a scheme. Since the virus can be carried even in the frozen carcase, imports into the United Kingdom are prohibited. Expansion of the internal meat trade in Africa, on the other hand, seems a most feasible proposition; though radical improvements in animal husbandry involving both social and economic changes will be needed before this can be achieved. Some system of organised marketing, cold storage and canning facilities will also be essential if a properly balanced meat industry is to be built up. As regards food grains, it is estimated that the world's need for rice will outstrip world production for many years to come, so that it is towards increasing this crop that attention has been specially given. Lack of suitable terrain sets a limit to its expansion, though considerable scope for immediate development lies in British Guiana, one of the few areas where a surplus is already produced. Possibilities for future extension are also being considered in certain regions of North Borneo, Sarawak and both East and West Africa.

Before the War, half the world production of the hard fibres used for marine cordage and binder twine came from the Philippines and the Netherlands East Indies, and a world shortage of this commodity still exists. The short-term need for sisal is being met in the Empire by increasing production in East Africa to the maximum; no extended planting of this crop is contemplated. The production of manila hemp, on the other hand, would probably be an economic proposition in North Borneo and Malaya, if certain disease difficulties could be overcome. Consideration of the world cotton situation has shown that a ready market exists in the United Kingdom for additional supplies of a staple length between $\frac{13}{16}$ and $1\frac{1}{16}$ in., the bulk of the present Colonial production being of longer staple than this. The possibilities of increasing the output of the required type are already being investigated, but improved agricultural methods as well as extended areas will be needed before much progress can be made.

Greater supplies of citrus fruits from the Colonies may be useful on grounds of currency; but there is at present no definite indication as to what the future demands for this commodity in the United Kingdom will be.

On the question of fertilizers, there is no doubt that a wider use of them would greatly increase Colonial crop production. As transport is one of the major difficulties, the discovery and working of local deposits, such as the phosphate recently found in Uganda, should prove particularly valuable. The setting up of plant for the manufacture of synthetic nitrogen, however, can only be envisaged as a scheme for the distant future, though it might well follow if the projected plans for the development of hydro-electric power in parts of Africa and Borneo materialize.

The work of the Committee is being continued, cocoa being the next product to come under discussion.

THE HUMAN FACTOR IN INDUSTRY

AT a time when the re-equipment of British industry is rightly commanding attention in terms of machinery and technical processes, a recent broadsheet* issued by P.E.P. gives a timely reminder of the reserves of human energy which are more quickly available to reinforce our efforts at increasing productivity. In order to release this energy, we must concern ourselves not merely with the more obvious problems such as the redistribution of manpower and the improved organisation of work, but also with the intangible factors affecting human relations and human attitudes in industry.

The broadsheet, after discussion of the general question of the application of scientific method to the study of industrial problems, surveys the research which has taken place in the United States and in Britain in the field of human relations in industry. In its second part an attempt is made to assess what is known about the factors influencing human relations in British industry; in this connexion there was a deliberate choice for examination of a number of industrial units the level of output and record of human relations of which were above the average, with the object of discerning any useful pointers to the kind of administrative pattern and managerial practice which lead to a high quality of human relations.

In general, research work of this type is much more advanced in the United States than in Great Britain. One of the early experiments that was conducted in the early 1920's at the Hawthorne plant of the Western Electric Company is now well known, and, discounting the unsafe generalizations about the applications of its findings in Britain, the broadsheet notes that its main lessons for us are the amount of information which can be gained by a well-balanced research team making a long-term and impartial inquiry, and the indications of the type of stimulus to which workers respond. The work of the American universities is noted both as to the inclusion of labour relations courses in curricula and also some interesting innovations such as the system whereby the trade unions, Congress of Industrial Organisations and American Federation of Labour, send to Harvard for a session a number of members ranging from vice-presidents to minor officials; the men may attend any lectures, and are required to write an essay relating the subjects studied with the work they are going to do in their union. Harvard has also given a professorship to a former vice-president of the Congress of Industrial Organisations on the condition that he continues his contact with organised labour as a consultant to the president of the Congress of Industrial Organisations, so that future business executives have the benefit of tuition from a practical trade union organiser.

Mention is made of the work in Great Britain of the National Institute of Industrial Psychology, the Tavistock Institute of Human Relations, the Medical Research Council and the Industrial Health Research Board; in the universities, departments of industrial relations have been established. But although the gap between industry and the universities is beginning to be bridged, there is still a long way to go before either can draw the full benefit of the experience and resources of the other. Scope for development is offered on a considerable scale by the new British Institute of Management, which will not only co-ordinate the work of other bodies on management research but will also conduct its own field work by balanced teams of investigators. Official encouragement may be expected from the newly appointed Committee on Industrial Productivity, one of the four panels of which will concern itself with human factors; but although the Medical Research Council and the British Institute of Management receive official funds, research activities generally in this field would benefit from financial assistance to other bodies.

In its assessment of the factors influencing human relations and attitudes in British industry, the broadsheet deals with methods of rate setting; joint consultation; disciplinary procedure; the stability of employment; placing, transfer and promotion; the quality and status of foremen. Under each of these headings some very interesting and instructive observations are made, as, for example, the application in the administration of industrial units of the principle of the separation and consequently the limitation of power: a case in point is the right to have a dispute settled by an independent section of management or by a joint committee, and not by an arbitrary decision of the immediate managerial representative. In discussing full employment, the point is made that to many, if not most, workers security of employment means security in their present jobs or at any rate in their present neighbourhood, so that a general condition of full employment may not necessarily remove the main cause of restrictive practices.

The broadsheet makes the modest claim that it represents no more than a preliminary reconnaissance of a part of the field of subjects affecting industrial productivity; but apart from its pointers to future research, this interim report has much to commend it in itself, and it will repay careful study by all those concerned to increase the effectiveness of human effort in industry.

* "The Human Factor in Industry", P.E.P. Planning Broadsheet, 14, No. 279, March 5, 1948.

PARALLELISM BETWEEN ATOMIC AND PLANETARY PROPERTIES

LAPLACE established the existence of a very simple numerical relation which holds to a high degree of approximation between the mean angular velocities of the first three satellites of Jupiter. M. F. Prunier, in a paper entitled "Quelques Observations et Expériences Nouvelles" (*Arch. Sci. phys. et nat.*, 28, Fas. 4 et 5, pp. 1–95; 1946), gives sixteen more such relations for satellites of various planets, though not all to the same degree of approximation. What is more, he gives a large number of simple numerical relations between the semi-major axes, eccentricities, masses and other constants relating to the planets themselves. It might be supposed that the existence of these relations is due merely to chance; but the author takes another view. He believes that they arise from a wave equation similar to Schrödinger's equation which governs the relations between the orbits of atomic physics. On this interpretation, the planets occupy orbits governed by a celestial wave mechanics. But Planck's constant h does not come into this new equation, and there is considerable difficulty in determining what shall replace it.

However, M. Prunier makes a number of suggestions for establishing a parallelism between atomic and planetary properties. Some of his arguments from analogy he himself describes as "un peu fragile", or "évidemment assez fragiles", but he considers the real justification of the analogies to lie in the results obtained. One of these concerns the magnetic moment of the earth, which he attributes to its angular momentum. His first attempt gives a numerical value about one-sixth of that observed, but afterwards a reason is found for multiplying this by 5, bringing it nearly to the value required.

M. Prunier, writing before the appearance of Prof. Blackett's much-discussed article on the magnetic field of massive rotating bodies (*Nature*, 159, 658; 1947), says (p. 52): "On est alors conduit à conclure à une relation entre le magnétisme d'une part, et la gravitation et la rotation des planètes d'autre part, de sorte que l'on aurait avec la gravitation des phénomènes magnétiques analogues à ceux que l'on a avec l'électricité, mais seulement beaucoup plus petits. Cela est étonnant dans l'état actuel des théories physiques, et nous ne devons pas y insister."

THE FOREST RESEARCH INSTITUTE OF SWEDEN

IN vol. 35 (1946) of *Meddelanden Fran Statens Skogs-Forskningsinstitut* (published by Centraltryckereit, Esselte, at Stockholm, 1947) there are some interesting papers.

The report opens with a thesis by Erik Bjorkman, well illustrated, on "Storage Decay in Pulpwood Yards and its Prevention". The value of such investigations at the present time needs no stressing. The author's research work has been carried out especially in Norrland, together with certain laboratory experiments concerning the life conditions for different storage-decay fungi. He has been able to form certain conclusions on the prevention of damage during storage in pulp-wood yards. During the Second World War, work in the pulp-wood factories was more or less at a standstill, large quantities of wood had to be stored in a limited space for an unforeseen period of several years, and in certain places decay made its appearance. That decay follows unsuitable storing or stacking methods has been long known. Apparently this applies more especially to floated pulp wood. The commonest fungus found in stored pulp wood of Scots pine and Norway spruce is *Stereum sanguinolentum* which, under unsatisfactory storage conditions, will make its appearance in the summer after the felling of the trees. Others developing early under certain conditions in coniferous wood and also very common are *Polyporus abietinus* and *Corticium evolens*. The latter is most common in birch, with other species of *Stereum* and *Polyporus*. These are termed the 'early rots'. The 'late rots' appear in long-stored coniferous wood that has not dried satisfactorily. These consist of species of *Poria*, *Trametes*, *Lenzites*, and others. If these fungi are allowed to develop, they will cause more damage than the 'early rots'. The latter mainly consume the lignin before the cellulose, whereas the former chiefly consume the cellulose.

The importance of storage decay in the manufacture of sulphite and sulphate pulps was studied in some hundred test boilings of pine and spruce wood stored for various periods and affected by different of the above-mentioned fungi. The author summarizes the most important results of these test boilings; and then gives a few practical applications of the investigations carried out.

A short paper by M. G. Stalfelt on "The Relation between the Poison Effect of Sodium Chlorate and the Methods of Distribution of the Salt" discusses experiments undertaken with sodium chlorate to poison heather (*Calluna vulgaris*) and bilberry (*Vaccinium myrtillus*). A weak solution causes temporary injuries. Only when a sufficient amount of the poison sticks to the basal part of the stem from which buds and shoots are developed will the part of the plant above ground be killed. Fine-grained salt will have greater action than coarse-grained. The best effects are obtained by spraying a concentrated solution with a fine douche. The spraying method requires 10–20 c.c. solution per square metre. Late spring (end of May) and early summer are the best periods to apply the poison.

Erik Bjorkman has a second paper with some interesting photographs of mills and floating logs entitled "On the Development of Log Stain and Storage Decay in Pine Saw-timber during Floating". Sweden is not the only country where such troubles occur, and with other species than the Scots pine. The aim of the author's research in this matter was to fix the time for, and the extent of, the storage injuries in the form of blue stain and storage decay originating in differently treated pine saw-timber during floating in North Sweden. This paper is well worth a study by those commercially interested in these matters.

FORTHCOMING EVENTS

Wednesday, May 19

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Discussion on "Tropical Meteorology".

ROYAL MICROSCOPICAL SOCIETY (at B.M.A. House, Tavistock Square, London, W.C.1), at 5.30 p.m.—Mr. N. S. McQueen: "The Work of Percy Smith".

ROYAL STATISTICAL SOCIETY, NORTH-EASTERN GROUP of the INDUSTRIAL APPLICATIONS SECTION (at the Newcastle Chemical Industries Club, 18 Lovain Place, Newcastle-upon-Tyne), at 6.30 p.m.—Mr. K. A. Brownlee: "Experiments in Industrial Chemistry".

Thursday, May 20

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 4 p.m.—Annual General Meeting; at 5.15 p.m.—Mr. S. E. Taylor: Presidential Address.

CHEMICAL SOCIETY (joint meeting with the CHEMICAL and the PHYSICAL SOCIETIES of UNIVERSITY COLLEGE, in the Physics Department, University College, Southampton), at 5 p.m.—Prof. L. C. Pauling, For.Mem.R.S.: "Intermolecular Forces and Biological Specificity".

LONDON MATHEMATICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Symposium on "Some Recent Work in Number-Theory" (introduced by Prof. L. J. Mordell, F.R.S.).

CHEMICAL SOCIETY (joint meeting with the UNIVERSITY COLLEGE SCIENTIFIC SOCIETY, at University College, Hull), at 6 p.m.—Mr. R. P. Bell, F.R.S.: "Kinetics of some Organic Halogenation Reactions".

ROYAL STATISTICAL SOCIETY, TEES-SIDE SUB-GROUP of the INDUSTRIAL APPLICATIONS SECTION (at the William Newton School, Norton, Stockton-on-Tees), at 7 p.m.—Mr. K. A. Brownlee: "The Use of the Factorial Experiment for Investigating Chemical Processes".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. J. D. Bernal, F.R.S.: Victor Moritz Goldschmidt Memorial Lecture.

Friday, May 21

CHEMICAL SOCIETY (at King's College, Newcastle-upon-Tyne), at 5 p.m.—Prof. A. R. Todd, F.R.S.: "Modern Theories of the Mechanism of Drug Action" (Bedson Club Lecture).

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, Kensington Gore, London, S.W.7), at 5.30 p.m.—Mr. Frank Chichester: "Meteorology in Aviation—Is it Obsolete?"

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Prof. J. T. MacGregor-Morris: "Great Personalities in the Fields of Electrical and Magnetic Measurements".

ROYAL SOCIETY OF MEDICINE, RADIOLOGY SECTION (at 1 Wimpole Street, London, W.1), at 8.15 p.m.—Annual General Meeting; Report on "The Million Volt Therapy at St. Bartholomew's Hospital" (Speakers: Mr. G. Innes, Dr. A. Jones, Mr. I. G. Williams, Dr. N. S. Finzi).

Saturday, May 22

NUTRITION SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 10.30 a.m.—Open Scientific Meeting and Annual General Meeting.

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (at the East Malling Research Station, East Malling Maidstone), at 12 noon.—Annual General and Summer Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (Grade III) IN MECHANICAL ENGINEERING—The Secretary and Registrar, The University, Bristol (May 29).

CHIEF INFORMATION OFFICER AND LIBRARIAN in the SCIENCE GROUP—The Director, Personnel Department, British Council, 3 Hanover Street, London, W.1 (May 29).

PLANT PATHOLOGIST under a Cocoa Research Scheme for the West Indies—The Secretary, Imperial College of Tropical Agriculture, Grand Buildings, Trafalgar Square, London, W.C.2 (May 30).

LECTURER IN PHYSIOLOGY—The Registrar, The University, Leeds 2 (May 31).

LECTURER IN ELECTRICAL ENGINEERING, and a LECTURER IN CIVIL AND BUILDING ENGINEERING—The Registrar, University College, Cathays Park, Cardiff (June 1).

CHAIR OF ZOOLOGY, a LECTURER IN MATHEMATICAL PHYSICS, and DEMONSTRATORS IN CHEMISTRY—The Secretary, Queen's University, Belfast (June 1).

UNIVERSITY LECTURERS and UNIVERSITY DEMONSTRATORS IN ENGINEERING—The Secretary of the Appointments Committee, Engineering Laboratory, Cambridge (June 1).

SENIOR RESEARCH OFFICERS or RESEARCH OFFICERS (2) IN THE DIVISION OF INDUSTRIAL CHEMISTRY, Melbourne—The Secretary, Australian Scientific Research Liaison Office, Australia House, Strand, London, W.C.2, quoting Nos. 1688–1689 (June 4).

PRINCIPAL RESEARCH OFFICER or SENIOR RESEARCH OFFICER IN THE DIVISION OF INDUSTRIAL CHEMISTRY, Melbourne—The Secretary, Australian Scientific Research Liaison Office, Australia House, Strand, London, W.C.2, quoting No. 1690 (June 4).

RESEARCH OFFICERS IN THE DIVISION OF ELECTROTECHNOLOGY at the National Standards Laboratory, Sydney—The Secretary, Australian Scientific Research Liaison Office, Australia House, Strand, London, W.C.2, quoting No. 1691 (June 4).

CHAIR OF ANATOMY at St. Thomas's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 7).

TECHNICAL ASSISTANT (Grade I) IN THE DEPARTMENT OF PATHOLOGY (including Bacteriology), The University, Cape Town—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (June 7).

RESEARCH WORKER (chemist with some training in physics or physicist with some training in chemistry) to conduct a systematic study of the melting, working and properties of certain glasses—The Secretary of the Glass Delegacy, The University, Sheffield 10 (June 7).

ASSISTANT LECTURER IN CHEMISTRY, and an ASSISTANT LECTURER IN BOTANY, University College of the West Indies, Jamaica—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (June 10).

SENIOR SOIL SURVEYOR, SOIL SURVEYORS (3), a SOIL CHEMIST, a SOIL CHEMIST (Spectrographer), and a SOIL PHYSICIST, under the Soils Research Scheme for the West Indies—The Secretary, Imperial College of Tropical Agriculture, Grand Buildings, Trafalgar Square, London, W.C.2 (June 15).

ASSISTANT LECTURER IN ELECTRONICS AND TELECOMMUNICATIONS—The Registrar, University College, Southampton (June 15).

PRINCIPAL—The Chairman to the Governors, Seale-Hayne Agricultural College, Newton Abbot, Devon (June 15).

ENGLISH ELECTRIC COMPANY BURSARS IN HYDRO-POWER ENGINEERING—The Dean, City and Guilds College, Exhibition Road, London, S.W.7 (June 30).

PRINCIPAL OF AUCKLAND UNIVERSITY COLLEGE, Auckland, New Zealand—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (June 30).

LABORATORY ASSISTANT (woman) at HABERDASHERS' ASKE'S HATCHAM GIRLS' SCHOOL, New Cross, S.E.14—The Education Officer (Estab. 2), London County Council, County Hall, London, S.E.1.

PROFESSOR (Research), ASSOCIATE PROFESSORS, ASSISTANT PROFESSORS, and LECTURERS, IN THE DEPARTMENT OF PHYSICS—The Dean of Arts and Science, University of Manitoba, Winnipeg, Man., Canada.

CHEMISTS (Scientific Officer and Experimental Officer grades) for research work on glasshouse crops—The Secretary, Experimental and Research Station, Cheshunt.

BIOLOGIST (female) FOR THE ENDOCRINE UNIT—The House Governor, London Hospital, Whitechapel, London, E.1.

JUNIOR ASSISTANT PHYSICIST—The Director, Medical Research Council, Radiobiological Research Unit, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

LABORATORY ASSISTANT (man) at Westminster Secondary Technical School, Buckingham Palace Road, S.W.1—The Education Officer (Estab. 2), London County Council, County Hall, London, S.E.1.

LECTURER IN ELECTRONICS—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks, endorsed 'Lecturer in Electronics'.

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